SUGAR BEET RESEARCH

1960 REPORT

Compiled by Sugar Beet Investigations

CROPS RESEARCH DIVISION
AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

CR-4-61

United States Department of Agriculture
Agricultural Research Service
Crops Research Division
Beltsville, Maryland

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1960 REPORT[1/]

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1/ This is a progress report of cooperative investigations containing data, the interpretation of which may be modified with additional experimentation. Therefore, publication, display, or distribution of any data or statements herein should not be made without prior written approval of the Crops Research Division, A.R.S., U. S. Department of Agriculture, and the cooperating agency or agencies concerned.

CR-4-61

FOREWORD

Sugar Beet Research is issued annually by Sugar Beet Investigations as a compilation of current reports of staff members and cooperators. The Report serves primarily as a medium of presenting results of investigations that have been strengthened by contributions from the Beet Sugar Development Foundation and as a means of reporting research accomplishments under Cooperative Agreements between Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and the Beet Sugar Development Foundation; the Farmers & Manufacturers Beet Sugar Association; and the Union Sugar Division, Consolidated Foods Corporation.

The individual reports and results of field tests from various sources have been compiled for the most part according to subject matter and objective of the research. The various groupings constitute Parts of the Report. The pertinent Foundation project has been indicated on the title page for various Parts.

Some of the investigations reported by staff members of Sugar Beet Investigations, as well as by Cooperators, have not been supported by the Beet Sugar Development Foundation; therefore, a Foundation project number on a title page should not be construed as meaning that all investigations reported in the Part received Foundation support.

Cooperative field tests conducted by State Agricultural Experiment Stations, the Farmers & Manufacturers Beet Sugar Association, and Agricultural Departments of Beet Sugar Companies have added greatly to the information concerning variety performances. The cooperation, as it applies, has been indicated on the title page of various Parts.

PREFACE

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HIGHLIGHTS OF ACCOMPLISHMENTS[1/]

New Inbreds, Varieties, and Hybrids.- During 1960, Sugar Beet Investigations made available to the Beet Sugar Development Foundation 18 new developments in breeding research under provisions of a Memorandum of Understanding. The items proposed for seed increase and utilization have been described on pages 7 through 11. The plan of utilization of the items by members of the Foundation is given on pages 12 through 14. Small quantities of seed of most of the items proposed for increase were supplied to members of the Foundation, thereby permitting company breeders to explore immediately the potential value of the items in their breeding programs.

Seed productions in 1960 of items proposed for seed increase in 1959 are given on page 15. The descriptions of these items proposed for seed increase and utilization in 1959 are given on pages 7 through 11 of the 1959 Report.

Plant breeders of sugar companies were supplied, through the Beet Sugar Development Foundation, 14 additional special items of breeding material developed by the staff of Sugar Beet Investigations.

Monogerm Seed Production.--Sugar beet seed production in this country is summarized annually in Agricultural Statistics. A breakdown of these production records, showing the trend to monogerm varieties, has been given on page 16.

The striking increase in the proportion of monogerm seed--from 3.7 percent in 1956 to 60.0 percent in 1960--is a development worthy of note. It seems fitting to present the remarkable advance in monogerm seed production in Part I of this report, since much of the basic breeding material that is currently involved in monogerm hybrids and varieties was originally presented in Part I of Sugar Beet Research.

If the characteristic of the majority reflects the image of the whole, then the sugar beet of 1960 in this country becomes a new creation--a plant producing single-seeded fruits. The production of flowers in clusters of two to several which cohere during maturation, forming multiseeded fruits, is a salient character of all subspecies and cultivars of Beta vulgaris, including the sugar beet. Thus the establishment of a sugar beet with single-seeded fruits represents a profound change in the structure and morphology of the plant and introduces a new botanical character in the taxonomy of Beta vulgaris. In the section Corollinae of the genus Beta, the key to the separation of species is based largely on germness and size of fruits. Therefore, it can be contended that after 1960 a botanical entity of a higher order than the usual concept of a cultivar will be used as the major source plant for sugar production on the mainland of this country.

1/ by Dewey Stewart

Exploitation of the full potential of monogerm seed in the reduction of labor requirements for thinning and weeding sugar beets will greatly overshadow the botanical aspects of the new plant. The sugar beet is a product of modern science, and the development of varieties with single-seeded fruits is another instance in which research has fashioned the plant to make it a more efficient source of sugar. But there is still much work to be done.

Breeding for Curly Top Resistance and for Varietal Improvement. - The variety tests conducted under severe curly top exposure at Jerome, Idaho, by A. M. Murphy, permit valuable appraisal of breeding material for disease resistance. For several years, these tests have supplied basic information for varietal improvement with respect to curly top resistance. In Test 1 at Jerome, the multigerm hybrid SL 942 (CT5 aa X CT9A) for the three dates of planting--April, May, and June--gave root yields and gross sugar significantly above those of CT5 aa, the most vigorous parent.

The hybrid SL 932 (CT5 aa X CT9 mm), in which the pollen parent was monogerm, gave a performance in gross sugar per acre that was significantly above CT5 aa, but the difference did not reach significant level for root yield. This hybrid is of special interest, since its sucrose percentage was significantly above that of the higher parent. In this test the hybrid gave a greater manifestation of heterosis for sucrose percentage than for root yield. If subsequent tests confirm the results of 1960, this hybrid will be another example of heterosis of sugar percentage in sugar beets.

The records of curly top damage in Test 1 are of interest. In all three dates of planting there is a definite trend for the curly top damage in the hybrid to approximate the mean of the parents, without an evident display of dominance for either resistance or susceptibility. However, it is evident that the most resistant lines and hybrids suffered severe damage in late plantings, which permitted infection to occur in the early stages of plant development, and that there is need for higher levels of resistance in young sugar beets to cope with the likelihood of early movements of the leafhopper in sugar beet districts.

The comparisons of multigerm SL 211H3 (US 22MS) and the monogerm SL 7121MS (which were developed by F. V. Owen), in hybrid combinations with 5 multigerm and 4 monogerm pollinators, showed a slight difference in root yield and gross sugar in favor of SL 7121MS X multigerm pollinators over the hybrids obtained with SL 211H3 and the same pollinators. In the tests conducted at Taylorsville, by Ryser and Smith, where curly top was not a factor in the growth of the plant, the difference in favor of SL 7121 did not prevail for the multigerm pollinators as in the test at Jerome.

The variety tests conducted at Brawley, California, by K. D. Beatty, clearly indicate that the variety trials at that station can supply valuable information as early as April on the performances of breeding material. This information serves a useful purpose in guiding the breeder

in formulating plans for selection and hybridizations in advance of the usual date of harvest in other districts.

The variety tests conducted by J. C. Overpeck in 1960--a year when curly top did not reach its usual level of intensity at the New Mexico Agricultural Experiment Station--demonstrate that excellent yields of sugar beets can be obtained in the lower Rio Grande Valley (page 43).

Nutrition and Quality. - The application of 120 pounds of nitrogen per acre as a side dressing at midseason induced additional top growth but no significant increase in average root yield, in a variety test conducted by K. D. Beatty at Brawley, California. The sucrose percentage (0.91) was lower in the area receiving additional nitrogen fertilizer.

Studies by Myron Stout on the nutrition of the sugar beet have confirmed his previous reports that redistribution of nitrates in the soil through the evaporation of soil moisture can be a controlling factor in the response to fertilizer applications. His studies on factors bringing about movement and concentration gradient of nitrate with rainfall and irrigation practices should supply information for the development of better control of nitrate uptake and quality of sugar beets.

Breeding for Resistance to Nematodes and Root Rot Disease. - Extensive field tests with progenies of plants selected for resistance to the sugar beet nematode have shown in the research of Charles Price that 90 percent of the progenies of selected plants were higher in root yield than US 41, when grown under severe nematode exposure. Progress is being made in the development of techniques for the study of crop rotation and soil amendments as factors in nematode control.

The results of a field test conducted by J. O. Gaskill to evaluate the progeny of plants that had been selected for resistance to *Rhizoctonia solani* were inconclusive, but one variety derived from selected plants showed, under exposure to the pathogen, a disease grade significantly lower than that of US 401. Inoculations were conducted in a similar field test with 226 introductions of exotic forms of *Beta vulgaris*. Ten of these had a lower disease grade than US 401, but these accessions were distinctly annuals under field conditions at Fort Collins. Investigations of J. H. Altman and J. O. Gaskill have shown a trend toward a reduction in Rhizoctonia infestation of soil and a lower incidence of disease in stands of sugar beet seedlings, as a result of applications of soil amendments such as barley straw and barley straw plus nitrate.

Screening tests conducted in the greenhouse by C. L. Schneider did not reveal an accession outstanding in resistance to black root (*Aphanomyces cochlioides*) among a large number of culinary and exotic forms of *Beta vulgaris*. Among 20 accessions of *Beta maritima*, 2 were found to be as resistant to the black root pathogen as US 401 (page 306).

Breeding Procedures. - In Part VIII, LeRoy Powers and R. J. Hecker have presented an example of the application of the partitioning method of genetic analysis to sugar beet breeding.

Interspecific Hybrids. - Definite progress has been made by Helen Savitsky in the production of backcross populations from hybridizations of tetraploid sugar beets with *Beta patellaris*, *B. procumbens*, and *B. webbiana*. Some of the segregants in the backcross generations displayed a blending of the characters of both parents. This strongly suggested that chromosomes or segments of chromatin material from the wild species have been transferred through cytological processes to plants that are predominantly like sugar beets. These new interspecific hybrids will be evaluated for nematode resistance at Salinas in 1961.

Hybridizations of *Beta webbiana* and *B. procumbens* with the sugar beet have been made by B. L. Hammond. These hybrids are under evaluation with respect to viability and usefulness in the breeding program.

Further studies are being pursued by G. E. Coe on the advanced generation from the hybridization of sugar beet and *Beta trigyna* (N = 36). Breeding material of economic significance has not been recovered from these crosses but they are supplying material for basic studies concerning the cytology and the interrelation of Beta species.

Polyploidy in Relation to Root Yield and Sucrose Percentage. - The evaluation of ploidy levels in hybrid combinations of sugar beets by V. F. Savitsky has important implications in planning breeding programs for sugar beet improvement through the utilization of the vigor of hybridity. The extensive cytological work conducted by Helen Savitsky, which established tetraploid phases of the parental varieties and lines, made possible the excellent experimental program on ploidy evaluation. Tetraploidizing five varieties resulted in a trend toward higher sucrose percentage in the tetraploids than in their diploid parental variety, and for the inbred line SLC 91MS, the increase in sucrose percentage was statistically significant at the 5-percent point. The root yield was increased by tetraploidization of four of the five varieties, and for US 104 and US 401 the increase in the tetraploid was significant at the 5-percent point. In these tests, the tetraploidization of US 401 resulted in concomitant increase in both yield and sucrose percentage. Further investigation is needed to determine the reason for this striking improvement in tetraploid US 401.

An appraisal was made of the combining ability of SLC 91MS with the monogerm variety SLC 15 and the multigerm varieties US 35/2, US 104, and US 401, at the diploid and tetraploid level. The expression of hybrid vigor for the two levels of ploidy was not significantly different for each of the parental combinations. Therefore, in the comparisons where each parent contributed an equal portion of the genomes to the hybrid, whether diploid or tetraploid, there is no significant difference in productivity or in sucrose percentage that can be attributed to ploidy level for a specific parental combination.

The triploid hybrids were obtained from two types of pollination--diploid SLC 91MS X tetraploid pollinator and tetraploid SLC 91MS X diploid pollinator. In both combinations of the various parents, root yield was significantly higher for the triploid hybrid, which suggests the importance of the triploid genome, irrespective of the parent that contributes the extra set of chromosomes.

The investigations of J. S. McFarlane and I. O. Skoyen (page 177), which involved the hybridizations of the male-sterile diploid line of C7569HO and the F_1 of NB1 X NB4 with European pollinators, did not demonstrate superiority of the triploid hybrids over their respective tetraploid pollen parent. The tetraploid pollinators were productive varieties and generally were higher in root yield than either of the diploid seed parents. None of the 14 triploid hybrids differed significantly from its tetraploid pollinator in root yield or in sucrose percentage in either of the two dates of planting. The average root yield for the two dates of planting was 37.7 tons per acre for the 7 triploid hybrids derived from MS of C7569HO X tetraploid and 38.5 tons for the 7 tetraploid pollinators; for the 7 triploid hybrids derived from (MS of NB1 X NB4) X tetraploid, the average root yield was also 37.7 tons per acre, and for the 7 tetraploid pollinators, 38.2 tons. In these 14 combinations of diploid seed parent X tetraploid pollen parent, the superiority of the triploid hybrids over the tetraploid pollinators was not demonstrated.

Development of Productive Hybrids. - The excellent performances of hybrid varieties developed in the breeding research of J. S. McFarlane and coworkers have been reported in previous issues of Sugar Beet Research. The cooperative field tests included in Part VII of this Report demonstrate a continuing high level of gross sugar production for the hybrids, which ranges from 5 to 40 percent above that for US 75, and some improvement in sucrose percentage over the open-pollinated variety.

A new hybrid variety, (MS of NB1 X NB5) X 663, has been designated US H6. In tests of 1957-1960, the average gross sugar production in the coastal districts of California and in the Imperial Valley was approximately 16 percent higher for US H6 than for US 75.

Cooperative tests conducted in the Great Lakes region have shown that the monogerm hybrid SL 122MS X SP 5460-0, as well as the hybrids SL 122MS X SP 5481-0 and SL 122MS X SP 5510-0, are approximately equal to US 401 in root yield and sucrose percentage. There is need for higher levels of resistance to leaf spot and black root in the hybrids, but until further improvement is made in monogerm parentage for the Great Lakes region, these hybrids are acceptable replacements for the multigerm variety US 401.

Virus Yellows Investigations and Leaf Spot Control. - The virus disease originally described by J. E. Duffus as radish yellows has assumed greater significance as a hazard to sugar beet production in California, Utah, Idaho, Oregon, and Washington. The disease has been designated "Western Yellows." The relative importance of virus yellows and western yellows of the sugar beet is given in the reports by C. W. Bennett (page 105) and by J. E. Duffuss and J. M. Fife (page 125). Bennett reports that some varieties of sugar beets infected with virus yellows are more susceptible to curly top, which confirms a previous report by N. J. Giddings. On the contrary, it was observed in a field test by McFarlane, Bennett, and Skoyen that one hybrid variety infected with virus yellows suffered less damage from rust.

The experiment by H. L. Bissonnette did not demonstrate significant gains in root yield from applications of fungicides for the control of leaf spot.

PART I

NEW DEVELOPMENTS IN BREEDING RESEARCH

Items Proposed for Seed Increase

Utilization and Distribution of Items

Seed Production of 1959 Items

- - - - -

PRODUCTION OF MONOGERM SEED IN U.S.A.

NEW DEVELOPMENTS IN BREEDING RESEARCH

Items Proposed for Seed Increase
June 2, 1960

Breeder seed, inbred lines, and varieties, which have been developed in the breeding research of Sugar Beet Investigations, are proposed for seed increase through the Beet Sugar Development Foundation. Seed not needed for planting overwintering plots will be furnished on request to company members of the Foundation for utilization in their breeding programs. Brief descriptions, current designations, and estimates of seed available August 1 are given for the items.

These new products of breeding research have been developed by the staff of Sugar Beet Investigations in cooperation with:

Colorado Agricultural Experiment Station
Michigan Agricultural Experiment Station
Minnesota Agricultural Experiment Station
New Mexico Agricultural Experiment Station
Beet Sugar Development Foundation
Farmers & Manufacturers Beet Sugar Association
Union Sugar Division, Consolidated Foods Corp.

Items Proposed for Seed Increase and Utilization

I. U. S. Sugar Beet Field Station, Salt Lake City, Utah.

Item 1. Monogerm SLC S-23 - - - - - 1/2 pound

Self-fertile diploid inbred line that is leaf spot resistant and green (rr) hypocotyl. In 1959 field test conducted at Fort Collins, Colo., under severe leaf spot exposure, SLC S-23 was found to be highly resistant. The disease readings for SLC S-23, US 201, US 201B, and US 216 were 0.5, 1.0, 2.0, and 4.0, respectively. (Developed by V. F. Savitsky with cooperation of J. O. Gaskill.)

Item 2. Tetraploid US 401 - - - - - 1 pound

A tetraploid strain of the multigerm variety US 401 that should be increased and evaluated as a pollinator in the production of triploid hybrids--preferably monogerm hybrids using SLC 122MS and other male-sterile monogerm lines as seed bearers.
(Developed by Helen Savitsky.)

Item 3. SL 0410 - - - - - - 1 pound

Originally from US 201B (multigerm) and selected by C. W. Bennett for resistance to Strain 11 of the curly top virus. Parentage of SL 0410 stems from two self-sterile plants selected from US 201B, and surprisingly, both were heterozygous (Aa) for the Mendelian factor conditioning male sterility. Breeder Seed SL 0410 was harvested from male-sterile plants (aa aborted pollen) and Breeder Seed SL 010 (Item 4) from pollen-fertile plants of the same production. SL 0410 should segregate, giving 50 percent aa plants that are male sterile. By appropriate roguing to male-sterile plants, SL 0410 may be readily hybridized. Additional information is needed on combining ability and resistance to leaf spot and curly top--including Strain 11.

An F_2 (SL 727), from the same parentage as SL 0410, was tested in 1958. See Sugar Beet Research, 1958 Report, pp. 244-249, for data supplied by Gaskill, Coe, and Murphy, showing moderate resistance to curly top and leaf spot.

Item 4. SL 010 - - - - - - - 1 pound

Originally from US 201B and of the same parentage and seed production as SL 0410 (Item 3), but Breeder Seed SL 010 was harvested from pollen-fertile plants. Therefore, not more than 25 percent of the plants of SL 010 should be aa, or male sterile.

Item 5. CT5A-0 - - - - - - - 200 grams

Self-fertile, green (rr) hypocotyl, multigerm, "TypeO" inbred line that is segregating for aa Mendelian male sterility. In populations of CT5A-0, 50 percent of the plants should be male sterile. (See Item 6 for Breeder Seed from pollinators.)

Item 6. CT5A - - - - - - - 400 grams

This Breeder Seed is the same as CT5A-0 (Item 5), except that seed was harvested from pollinators. In populations of CT5A, not more than 25 percent of the plants should be male sterile (aa). In the Brawley test, which was harvested April 1960, hybrids with CT5A were among the best hybrids in the test. CT5A has been subjected to 3 generations of inbreeding , in addition to 2 generations of brother-sister mating; therefore, vigor is reduced. The Brawley information indicates that the line is one of the more easy-bolting sublines of CT5.

Item 7. Monogerm SLC 129-0(rr) 1 pound

Green (rr) hypocotyl, monogerm, "Type O" inbred line carrying factors for aa Mendelian male sterility. In populations of SLC 129-0(rr), 50 percent of the plants should be male sterile (aa). SLC 129-0(rr) is an increase of SLC 129-0 which was distributed in 1959, but this Breeder Seed has been rogued to green (rr) hypocotyl plants.

Item 8. SLC 129 - - - - - - - 1 pound

This Breeder Seed is the same as SLC 129-0(rr) (Item 7), except that the seed was harvested from pollen-fertile plants. In populations of SLC 129, not more than 25 percent of the plants should be male sterile (aa).

Item 9. SLC 129MSmm - - - - - - 1 pound

Cytoplasmic male-sterile monogerm line representing the second backcross to SLC 129 (Item 8).

Item 10. SLC 133 (SL 7401) - - - - - 2 pounds

A monogerm, green (rr) hypocotyl inbred whose offspring in tests of 1958 indicated it to be a yield type. A monogerm MS hybrid to SLC 133 (SL 7121) was used extensively in 1959 as a standard MS monogerm for combining ability tests. In the 1960 harvest at Brawley, some of these hybrids gave excellent yields. Several SLC 133 hybrids have shown excellent vigor as seed plants. The hybrid with SLC 129 produced especially vigorous seedstalks. SLC 133 does not segregate for Mendelian male sterility and is therefore regarded as a "++" monogerm pollinator.

Item 11. SLC 133MS (SL 7121) - - - - 1 pound

SL 7121 is the male-sterile line used extensively for combining tests in 1959. It is suggested that SLC 133MS be backcrossed to SLC 133 (Item 10) for the production of an additional supply of seed. Some roguing to white anther (MS) may be desired.

II. U. S. Agricultural Research Station, Salinas, California.

Item 12. C0562 - - - - - - - 1 pound

This "Type O" monogerm inbred carries resistances to both bolting and curly top. It represents an increase of an F_3 selection from a cross between NB1 and the bolting resistant C8507 inbred. In the 1959 test at Jerome, Idaho, C0562 was similar to US 75 and slightly inferior to NB1 in curly top resistance. Bolting resistance is similar to that of NB1. Combining ability tests have not been made.

Suggested utilization: (a) Small increase of C0562; (b) an additional backcross to C0562HO (Item 13) to reproduce the male-sterile equivalent; and (c) production of F_1 hybrids using C0562 as the pollen parent and the male steriles F59-515HO and F59-569HO as seed parents.

Item 13. C0562HO - - - - - - - 2 pounds

This male-sterile monogerm represents the second backcross to C0562 (Item 12) type monogerms.

Item 14. C0562H1 - - - - - - - 2 pounds

This is the F_1 monogerm hybrid, MS of 7515 X C0562. It should possess good bolting resistance, moderately good curly top resistance, and complete male sterility. It is suggested for use as a male-sterile monogerm parent in the production of experimental quantities of 3-way hybrids.

III. Sugar Beet Investigations, Fort Collins, Colorado.

Item 15. SP 601000-0 - - - - - - 1/2 pound

A self-sterile monogerm synthetic variety that carries resistance to leaf spot and black root. In addition, there has been the equivalent of one generation of selection for storage rot (Botrytis) resistance. In a replicated test of 1959, which was conducted under severe leaf spot exposure at Fort Collins, this monogerm variety was equal to US 401 in leaf spot resistance, root yield, and sucrose percentage.

In the breeding history of SP 601000-0 there has been selection for Botrytis resistance. Furthermore, the multigerm parent in the final backcross was SP 5460-0. The field performances of this Breeder Seed, as well as its breeding history, suggest that it may have value as a pollinator in the production of monogerm hybrids.

IV. Sugar Beet Investigations, Beltsville, Maryland.

Item 16. SP 6045-0 - - - - - - 5 pounds

A monogerm synthetic variety produced by the interpollination of 11 selfed progenies. The polycross progeny of each of these stem-mothers did not differ significantly from US 401 in root yield and sucrose percentage but was slightly better in resistance to leaf spot and black root.

The history of backcrossing and determination of breeding value of mother plants give reasonable expectation that the synthetic variety SP 6045-0 will give good performances. A seed increase is suggested, as well as the use of SP 6045-0 as a pollinator with male-sterile monogerm lines.

Item 17. SP 60300-0 - - - - - - 1 pound

A monogerm synthetic variety that should carry high resistance to leaf spot and black root. The Breeder Seed will represent a pooling of seed of the best polycrosses as revealed in 1960 nursery tests at Beltsville, Md., East Lansing, Mich., and Waseca, Minn. SP 60300-0 should carry a high level of disease resistance and its yield should approach that of US 401. The actual level of performances will have to be determined from field trials in various sugar beet districts. A seed increase is suggested.

Item 18. SP 5822-0 - - - - - - 1 pound

A multigerm synthetic variety that is better than US 401 in resistance to leaf spot and black root. Under severe disease exposure, it has been superior to US 401 in root yield. Results of field tests in which SP 5822-0 was an entry are given in Sugar Beet Research, 1959 Report, pages 250-257. A small increase of SP 5822-0 is being made at Beltsville and also by the Great Western Sugar Company. Seed can be made available for further increase.

BEET SUGAR DEVELOPMENT FOUNDATION
P. O. BOX 538
FORT COLLINS, COLORADO

UTILIZATION OF USDA SEED RELEASES, 1960

Items by number correspond to those listed in release memorandum 1/

1. U. S. Sugar Beet Field Station, Salt Lake City, Utah

Item 1. Monogerm SLC S-23
No increase of this release has been requested. The following companies have requested 10 grams be sent to them now: American Crystal Sugar Company, Utah-Idaho Sugar Company.

Item 2. Tetraploid US 401
A .1 acre increase of this release will be made by the West Coast Beet Seed Company for the American Crystal Sugar Company and the Farmers and Manufacturers Beet Sugar Association. The following companies have requested 10 grams be sent to them now: American Crystal Sugar Company, Farmers and Manufacturers Beet Sugar Association, The Great Western Sugar Company, Holly Sugar Corporation, Spreckels Sugar Company, and Utah-Idaho Sugar Company.

Item 3. SL 0410
No increase of this release has been requested. From the available quantity the following amounts are to be distributed now to the companies listed: The Amalgamated Sugar Company - 10 grams, American Crystal Sugar Company - 10 grams, Holly Sugar Corporation - 25 grams, Spreckels Sugar Company - 10 grams, and Utah-Idaho Sugar Company - 15 grams.

Item 4. SL 010
No increase of this release has been requested. From the available quantity the following amounts are to be distributed now to the companies listed: The Amalgamated Sugar Company - 10 grams, Holly Sugar Corporation - 25 grams, and Utah-Idaho Sugar Company - 10 grams.

Item 5. CT5A-0
The available seed of this release will be sent to the Utah-Idaho Sugar Company for a .1 acre increase at St. George, Utah. No further distribution will be made at this time.

Item 6. CT5A
The available seed of this release will be shipped and utilized as shown for Item 5 above.

1/ Proposed for increase and utilization in memorandum letter from Dewey Stewart, Leader, Sugar Beet Investigations, USDA, dated June 2, 1960.

Item 7. Monogerm SLC 129-0(rr)

Sufficient seed for a .1 acre increase will be sent to the Utah-Idaho Sugar Company for a .1 acre increase at St. George, Utah. The following companies have requested 10 grams be sent to them now: American Crystal Sugar Company and Spreckels Sugar Company.

Item 8. SLC 129

Sufficient seed for a .1 acre increase is to be sent to the Utah-Idaho Sugar Company for increase at St. George, Utah. The Great Western Sugar Company wishes to have 10 grams sent to them now.

Item 9. SLC 129MSmm

Sufficient seed for a .1 acre increase is to be sent to the Utah-Idaho Sugar Company for increase at St. George, Utah. The following companies have requested 10 grams be sent to them now: American Crystal Sugar Company, Great Western Sugar Company, and Holly Sugar Corporation.

Item 10. SLC 133 (SL 7401)

Sufficient seed for a .1 acre increase is to be sent to the Utah-Idaho Sugar Company for increase at St. George, Utah. The following companies have requested the amounts shown be sent to them now: The Amalgamated Sugar Company - 10 grams, American Crystal Sugar Company - 10 grams, The Great Western Sugar Company - 10 grams, Holly Sugar Corporation - 25 grams, and Spreckels Sugar Company - 10 grams.

Item 11. SLC 133 MS (SL 7121)

Distribution and utilization identical with that shown for Item 10, above.

II. U. S. Agricultural Research Station, Salinas, California.

Item 12. C0562

Item 13. C0562H0

A one acre planting of the above two items will be made in combination with other strains. The arrangements have been made with the West Coast Beet Seed Company for planting these items and will be jointly and equally conducted for the following companies: American Crystal Sugar Company, Farmers and Manufacturers Beet Sugar Association, Holly Sugar Corporation, Spreckels Sugar Company, and Union Sugar Division of Consolidated Foods Corporation. No additional seed shipments will be made at this time.

Item 14. C0562H1

No increase of this release has been requested. The available quantity (approximately 1/2 pound to each) will be distributed now to the following companies: American Crystal Sugar Company, Holly Sugar Corporation, Spreckels Sugar Company, and Union Sugar Division of Consolidated Foods Corporation.

III. Sugar Beet Investigations, Fort Collins, Colorado

Item 15. SP 601000-0

No increase of this release has been requested. The following companies have requested 10 grams be sent to them now: American Crystal Sugar Company, Farmers and Manufacturers Beet Sugar Association, Great Western Sugar Company, Holly Sugar Corporation, Spreckels Sugar Company, and Utah-Idaho Sugar Company.

IV. Sugar Beet Investigations, Beltsville, Maryland

Item 16. SP 6045-0

An increase of size to be agreed upon will be made by the West Coast Beet Seed Company for the Farmers and Manufacturers Beet Sugar Association and The Great Western Sugar Company. From the available quantity, 10 grams will be distributed now to the following companies: American Crystal Sugar Company, Holly Sugar Corporation, Spreckels Sugar Company, and Utah-Idaho Sugar Company.

Item 17. SP 60300-0

A .1 acre increase will be made by the West Coast Beet Seed Company for the Farmers and Manufacturers Beet Sugar Association and The Great Western Sugar Company. From the balance, the following companies have requested the amounts shown be sent to them now: American Crystal Sugar Company - 10 grams, Holly Sugar Corporation - 25 grams, Spreckels Sugar Company - 10 grams, and Utah-Idaho Sugar Company - 10 grams.

Item 18. SP 5822-0

No increase of this release has been requested. From the available quantity the following amounts are to be distributed now to the companies listed: American Crystal Sugar Company - 10 grams, Holly Sugar Corporation - 25 grams, Spreckels Sugar Company - 10 grams, and Utah-Idaho Sugar Company - 10 grams.

July 14, 1960
60-17
WMF

1960 Seed Productions of 1959 Proposals for Seed Increase
(See 1959 Report, pp. 7-11)

1959 Proposals	1960 Productions	
Item	Description and Designation of Production	Seed (lbs.)
1	Tetraploid SLC 91 mm: No report of seed production although a probable increase by the Amalgamated Sugar Company was indicated.	None
2	Male Sterile Tetraploid SLC 91 mm. Same plan as for Item 1.	None
3	SLC 129-0; No seed increase	None
4	SLC 129; No seed increase	None
5	SLC 129 MS; No seed increase	None
6	CT9A; No seed increase	None
7	C9561 (C9561-4) West Coast Lot No. 0472 and F60-561	82
8	C9561HO (C9561H2 X C9561-4) West Coast Lot No. 0468 and F60-561HO	28
8a	C9561-3HO X C9561-4 West Coast Lot No. 0469 and F60-561HOA	79
9	C9561H1 (F58-515HO X C9561-4) West Coast Lot No. 0470 and F60-561H1	30
9a	F58-85HO X C9561-4 West Coast Lot No. 0471 and F60-561H2	76
10	C951; No seed increase	None
11	C952; No seed increase	None
12	C953; No seed increase	None
13	C955; No seed increase	None
14	SP 5931-0; No seed increase	None
15	SP 59300-0; No seed increase	None
16	SP 591-0; No seed increase	None
17	SP 59E5-0; West Coast Lot No. 0465 .	107
A	SP 591103-0; West Coast Lot No. 0463	109
B	SP 451069-0; West Coast Lot No. 0464	110

Sugar Beet Seed Production in United States 1956-1960,

Indicating Trend to Monogerm Varieties

Year of Production	Multigerm	Monogerm	Total	Percent Monogerm
	bags1/	bags1/	bags1/	
1956	84,991	3,288	88,279	3.7
1957	83,812	10,735	94,547	11.4
1958	82,571	27,261	109,832	24.8
1959	83,594	28,194	111,788	25.2
1960	49,869	74,676	124,545	60.0

1/ 100-pound bags

Monogerm seed for experimental plantings and for stock seed was produced before 1956, but the first significant production of monogerm seed for grower use was in 1956. Monogerm seed, largely productions by the Utah-Idaho Sugar Co., constituted 3.7% of the crop in 1956. In 1960, seed of monogerm varieties and hybrids comprised 60% of the seed crop.

PART II

DEVELOPMENT AND EVALUATION OF INBRED LINES AND HYBRID VARIETIES OF SUGAR BEETS

with emphasis on

Curly Top Resistance
Monogermness and High Quality

Foundation Projects 22 and 23

F. V. Owen
A. M. Murphy
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Cooperators conducting field tests:

New Mexico Agricultural Experiment Station
Southwestern Irrigation Field Station, Brawley, California
Utah-Idaho Sugar Company

FOUNDATION PROJECT 22 - REPORT FOR 1960

Climate and Curly Top, Jerome, Idaho, 1960

From the time the beet leafhoppers entered the fields in southern Idaho conditions were highly favorable for the development of curly top; i.e., little shade at first, high temperatures, and low humidity.[1/] In June the mean temperature was 5.2° F. above normal, yet by a paradox of nature there was a frost on June 21. The low temperatures at this time did little apparent damage to the sugar-beet crop, but abrupt and extreme temperature changes are not conducive to good growth. The cool snap was of short duration, and above-normal temperatures immediately followed and continued into early August. According to the Twin Falls weather station, temperatures in July were the hottest on record: 4.8° F. above normal, with only 0.04-inch percipitation.

A generally over-all satisfactory curly-top exposure was obtained in the Jerome beet-breeding field for the screening of breeding material. The susceptible European variety, Klein E, used as a host for the beet leafhopper and the curly-top virus, was annihilated, even though planted in April. The contrast between this stricken variety, which at one time was used extensively for commercial planting in the Snake River Valley, and the performance of the 1960 commercial crop clearly demonstrates the ability of present varieties to perform well under severe curly-top exposure. However, when the varieties presently grown are compared in turn with some of the newer disease-resistant monogerm sorts, it is obvious that better varieties will eventually be available.

1/ In "statements" on Leafhopper Conditions in Southern Idaho, issued April 21, 1960, by the Extension Service, University of Idaho, based on surveys conducted by the U. S. Department of Agriculture, the statement is made that "During the past 24 years, the average initial spring movements have started May 25 and reached their peak on June 23."

TEST FIELD, JEROME, IDAHO, 1960

OWNER: Leon Aslett. Located six miles north and 1-1/2 miles west of Jerome, Idaho

CROP HISTORY: Alfalfa, 1952; sugar beets, 1953 to 1960 inclusive. Barnyard manure and commercial fertilizer used for all beet crops.

PREPARATION FOR 1960 CROP:

1. Spread 12 loads (70 bu. each) of cattle manure per acre March 21 and 22
2. Disced March 24
3. Broadcast 586 lbs. mixed fertilizer (24-20-0)
4. Plowed March 23-24
5. Harrowed and leveled to prepare proper seed bed
   First planting, April 25-26
   Second planting May 18-19
   Third planting June 13

To make the curly-top epidemic more severe for the second planting (May), crosswise strips of R.and G. Old Type(1-300) 15 feet wide were planted on April 28. Virus-containing mother beets were set out in every other row of these strips April 29.

IRRIGATIONS: All plantings irrigated immediately after planting and as often as necessary thereafter.

EXPERIMENTAL DESIGN: Test I is made up of two sets of randomized blocks consisting of four inbred varieties and four hybrid varieties, with six replications each. Test I was planted in April, May, and June and replicated six times each date of planting.
Test II was planted as a 5 X 6 rectangular lattice with six replications in April planting only. In May and June, Test II was not replicated but planted once for observation under curly top.
Tests III and VIII were planted in May and June only with one replication each date for observation. Tests IV, V, VI, VII, IX, X, and XI were planted in April and May plantings only with one replication for observation.
This report includes information only on the replicated tests.

PLOT SIZE: All plots consisted of two rows 50 feet long.

HARVEST OF REPLICATED TESTS: October 14-18.

EXPERIMENTAL RESULTS: Tests I and II are given in Tables 1 and 2, and summaries are given in Tables 3 and 14.

Table 1.

VARIETY TEST, JEROME, IDAHO, 1960

TEST I - Inbreds and Hybrids

(Six replicated plots of each variety)

S.L. NUMBER	DESCRIPTION	APRIL PLANTING ACRE YIELD GROSS SUGAR Pounds	APRIL PLANTING ACRE YIELD TONS BEETS	APRIL PLANTING PERCENT SUGAR	APRIL PLANTING PERCENT CURLY-TOP	APRIL PLANTING BEETS 100' ROW'	MAY PLANTING TONS PER ACRE	MAY PLANTING BEETS 100' ROW	MAY PLANTING PERCENT CURLY-TOP	JUNE PLANTING TONS PER ACRE	JUNE PLANTING BEETS 100' ROW	JUNE PLANTING PERCENT CURLY-TOP
	INBREDS											
9450	CT5 (803 aa X sibs)	7,793	22.9	17.0	9.8	97	18.0	86	32.2	6.7	47	41.9
9093	CT9.32 = S_4	5,681	16.9	16.8	13.1	87	13.7	66	45.6	7.0	52	55.3
9540	CT9 mm = F_3b_1	5,225	16.6	15.8	23.8	89	9.2	65	62.5	5.9	49	73.6
9096	CT9A = S_3	4,954	15.3	16.5	28.6	92	12.0	83	64.2	7.3	67	73.5
028*	US 41 (adjacent plots)	7,656	23.2	16.5	23.6	99						
General MEAN of all varieties		5,913	17.9	16.4			13.2		51.1	6.7		61.0
S. E. of MEAN		326	1.01	0.13			1.08			0.59		
Sig. Diff. (19:1)		981	3.04	0.40			3.25			NS		
S. E. of MEAN in % of MEAN		5.51	5.64	0.79			8.18					
Calculated F Values		15.65	11.29	18.4			11.66			NS		
	HYBRIDS											
942	CT5 aa X CT9A	9,389	27.9	16.8	15.5	112	22.2	103	51.2	12.2	68	67.3
932	do. X CT9 mm	8,750	25.0	17.5	16.4	109	20.5	105	47.8	11.6	77	64.2
E 790	CT5 X CT9	8,535	24.8	17.2	9.8	100	19.6	89	35.9	11.3	65	44.6
1002	F54-4H7 (CT9 MS X Klein E)	6,773	20.3	16.7	32.0	89	17.6	87	66.4	11.2	65	73.1
General MEAN of all varieties		8,361	24.5	17.0			19.9		50.3	11.5		62.3
S. E. of MEAN		287	0.848	0.14			0.866			0.59		
Sig. Diff. (19:1)		864	2.55	0.43			2.60			NS		
S. E .of MEAN in % of MEAN		3.43	3.46	0.82			4.37					
Calculated F Values		15.08	13.75	5.92			5.04			NS		

* Not included in general mean

Table 2.

VARIETY TEST, JEROME, IDAHO, 1960

TEST II

(6 replications of each variety)

VARIETY	DESCRIPTION	ACRE YIELD GROSS SUGAR		ACRE YIELD TONS BEETS	PERCENT SUGAR	PERCENT CURLY-TOP Sept. 9	BEETS 100' ROW
943	CT5 Mm aa X CT9 mm	8,561	(25)	25.3	17.0	16.2	103
950	(117X125) mm aa X CT5B	10,197	(2)	29.8	17.2	5.6	108
952	mm aa X CT5 type O	8,891	(20)	26.4	16.8	8.4	100
991	(117X125) mm aa X CT9A	9,113	(14)	27.0	16.8	10.2	112
9100	211H3 X CT5B	9,325	(9)	27.3	17.1	8.4	111
9101	do. X CT5A	9,330	(8)	27.4	17.0	10.4	107
9102	do. X CT5 type O	9,122	(12)	26.9	17.0	9.1	109
9103	do. X CT5 RR line	8,838	(21)	25.6	17.2	11.5	106
9104	do. X CT9-O	9,616	(4)	28.4	17.0	12.1	104
9105	do. X CT9A	8,966	(18)	25.9	17.3	15.6	115
9106	do. X CT9.95	9,069	(15)	26.3	17.3	11.3	108
9111	do. X SLC 131 rr mm	9,241	(10)	27.5	16.8	20.2	106
9112	do. X SLC 129 mm	8,898	(19)	26.0	17.1	16.9	112
9113	do. X SLC 128 mm	8,426	(26)	23.9	17.6	11.7	101
9116	do. X SLC 130 rr mm	8,975	(17)	26.1	17.2	9.8	112
9117	do. X CT9 mm	9,380	(7)	28.0	16.8	14.4	110
9121	7121 MS mm X CT5A	9,706	(3)	28.0	17.3	4.6	99
9123	do. X CT5 RR line	9,536	(5)	28.1	17.0	8.6	109
9124	do. X CT9-O	9,380	(6)	27.3	17.2	5.6	109
9125	do. X CT9A	9,162	(11)	26.8	17.1	6.8	106
9126	do. X CT9.95	9,115	(13)	26.4	17.2	7.1	112
9131	do. X SLC 131 rr mm	9,014	(16)	26.9	16.8	7.2	110
9132	do. X SLC 129 mm	8,579	(24)	25.1	17.1	8.4	110
9133	do. X SLC 128 mm	8,781	(22)	25.6	17.2	7.2	108
9137	do. X CT9 mm	8,764	(23)	25.2	17.4	10.2	98
9140	do. X CT5B	10,281	(1)	30.2	17.0	6.5	110
9367	E 915 Mm + mm X mm	7,831	(28)	22.5	17.4	27.7	101
9368	E 920 mm X (CT9 mm X mm)	8,256	(27)	24.5	16.8	26.6	104
028	US 41, 1st entry	7,337	(30)	21.6	17.0	22.5	99
028	do., 2nd entry	7,687	(29)	22.6	17.0	20.8	102
General MEAN of all varieties		8,970		26.29	17.08		
S. E. of MEAN		302		0.93	0.16		
Sig. Diff. (19:1		847		2.60	0.45		
S. E. of MEAN in % of MEAN		3.37		3.50	0.94		
Calculated F Values		4.64		4.43	1.63		

Table 3.

VARIETY TEST, JEROME, IDAHO, 1960
Comparisons of Monogerm and Multigerm Parentage 1/

POLLINATOR	ACRE YIELD				PERCENT SUGAR	
	GROSS SUGAR		TONS PER ACRE			
	Multi-211H3	Mono-7121 MS	Multi-211H3	Mono-7121 MS	Multi-211H3	Mono-7121 MS
	Multigerm pollinators					
CT5B	9,325	10,281	27.3	30.2	17.1	17.0
CT5A	9,330	9,706	27.4	28.0	17.0	17.3
CT5 RR	8,838	9,536	25.6	28.1	17.2	17.0
CT9-0	9,616	9,380	28.4	27.3	17.0	17.2
CT9A	8,966	9,162	25.9	26.8	17.3	17.1
CT9.95	9,069	9,115	26.3	26.4	17.3	17.2
General MEAN of all varieties	9,191	9,530	26.81	27.80	17.15	17.15
	Monogerm pollinators					
131 mm	9,241	9,014	27.5	26.9	16.8	16.8
129 mm	8,898	8,579	26.0	25.1	17.1	17.1
128 mm	8,426	8,781	23.9	25.6	17.6	17.2
CT9 mm	9,380	8,764	28.0	25.2	16.8	17.4
General MEAN of all varieties	8,986	8,784	26.35	25.70	17.07	17.12

VARIANCE TABLES

Variation due to	Degrees of Freedom	MEAN SQUARES		CAL. F. VALUES		SIG. F.
		GROSS SUGAR	TONS BEETS	GROSS SUGAR	TONS BEETS	5%
		Multigerm pollinators				
Between replications	5	639,718	8.91	0.89	1.39	2.38
" pollinators	5	1,031,654	11.17	1.44	1.75	2.38
" females	1	2,072,648	18.40	2.89	2.88	4.02
Pollinator X females	5	569,134	6.78	0.79	1.06	2.38
Error	55	716,956	6.39			
Total	71					
		Monogerm pollinators				
Between replications	5	493,538	6.79	1.07	1.44	2.38
" pollinators	3	624,656	13.81	1.36	1.94	2.88
" females	1	903,554	5.33	1.96	1.14	4.13
Pollinators X females	3	802,927	10.07	1.76	2.29	2.88
Error	35	460,312	4.40			
Total	47					

1/ Summary of data taken from Table 2.

VARIETY TEST, TAYLORSVILLE, UTAH, 1960

GROWER: Rell Swensen

SOIL TYPE: Welby fine sandy loam

PREVIOUS CROPS: 1955, grain to alfalfa; 1956 and 1957, alfalfa; 1958 grain; 1959, sugar beets.

FERTILIZERS AND CULTURAL PRACTICES: Applications of manure and commercial fertilizers were used in conjunction with previous crop rotation. About 15 spreader loads of chicken litter and 200 pounds of ammoniated phosphate (20-40) per acre were applied and worked into the soil during seed-bed preparation.

SOIL FUMIGATION: The soil was fumigated with Shell DD at 25 gallons per acre in October, 1959, by the plow method.

PLANTED: April 15

THINNED: Hand thinning, May 6.

IRRIGATIONS: First irrigation, May 20. A total of 13 irrigations by furrow.

CURLY TOP: Occasionally severe symptoms on susceptible varieties but very rare or absent in resistant varieties.

HARVESTED: October, 1960. At harvest the tops were removed with a roto-beater and beets scalped with tractor-mounted scalping tools supplemented by long-handled hoe work. Beets were counted before pulling. The center row was taken from each plot for sugar analysis. These samples were weighed after washing to ascertain tare percentage.

EXPERIMENTAL DESIGN: The variety tests considered in this report were of randomized block and 5 X 6 and 3 X 4 rectangular lattice designs. The beets were planted in 3-row plots with 20 inches between rows and effective plot length of 22 feet. Objective at thinning was 8-to 10-inch spacing. Four-foot alleys were cut between plots.

EXPERIMENTAL RESULTS: Summarized in Tables 4 to 11, inclusive, and in Table 14.

Table 4.

VARIETY TEST, TAYLORSVILLE, UTAH, 1960

TEST II

(6 replicated plots of each variety)

S. L. NUMBER	DESCRIPTION	ACRE YIELD GROSS	TONS	PERCENT SUGAR	PURITY	p.p.m. AMINO N	Na	K	BEETS 100' ROW
943	CT5 Mm aa X CT9 mm	9,122	32.8	13.9	86.3	4901	650	2982	104
950	(117 X 125) mm aa X CT5B	8,804	33.1	13.3	82.6	6318	732	3251	109
952	mm aa X CT5,type O	10,624	39.9	13.3	83.8	6551	680	3181	112
991	(117 X 125) mm aa X CT9A	10,097	36.3	13.9	84.2	6468	692	3104	112
9100	211H3 X CT5B	9,866	37.0	13.3	83.7	6200	675	3216	116
9101	do. X CT5A	9,130	36.0	12.7	81.9	6201	893	3319	106
9102	do. X CT5, type O	8,711	33.7	12.9	83.5	5951	795	3122	110
9103	do. X CT5 RR line	9,005	34.3	13.1	83.9	6618	720	3336	104
9104	do. X CT9-O	9,691	36.8	13.1	82.9	6985	783	3331	110
9105	do. X CT9A	9,171	34.9	13.1	83.9	6601	767	3044	118
9106	do. X CT9.95	8,709	33.1	13.2	84.1	6584	800	3247	113
9111	do. X SLC 131 rr mm	8,173	35.2	11.6	80.4	6151	967	3769	102
9112	do. X SLC 129 mm	9,395	35.1	13.4	83.9	6385	660	3331	106
9113	do. X SLC 128 mm	8,576	31.6	13.6	84.5	5434	587	3252	103
9116	do. X SLC 130 rr mm	9,098	34.5	13.2	83.2	6568	772	3367	108
9117	do. X CT9 mm	8,760	34.4	12.7	83.7	4818	733	3311	112
9121	7121 MS mm X CT5A	8,662	33.7	12.8	82.6	5851	972	3144	113
9123	do. X CT5 RR line	8,981	34.8	12.9	82.5	6818	762	3421	113
9124	do. X CT9-O	9,041	35.8	12.6	82.8	5580	957	3292	115
9125	do. X CT9A	8,943	34.2	13.1	83.2	6200	979	3342	113
9126	do. X CT9.95	9,235	36.3	13.4	84.3	5184	782	3094	112
9131	do. X SLC 131 rr mm	7,974	35.2	11.3	79.6	6985	1088	3824	105
9132	do. X SLC 129 mm	9,203	35.4	13.0	82.6	6001	695	3471	118
9133	do. X SLC 128 mm	9,433	35.0	13.5	84.3	5568	588	3317	110
9137	do. X CT9 mm	9,060	35.8	12.7	82.3	5468	778	3427	109
9140	do. X CT5B	10,022	37.8	13.3	83.3	6201	673	3274	113
9367	(E 915) Mm + mm X mm	8,837	31.9	13.7	83.5	6268	772	3477	102
9368	(E 920) mm X (CT9 mm X mm)	8,654	31.7	13.6	83.9	5668	627	3476	107
028	US 41, 1st entry	7,954	31.2	12.7	81.5	6100	937	3539	104
028	US 41, 2nd entry	7,637	30.7	12.4	81.6	6566	928	3626	113
General MEAN of all varieties		9,017	34.61	13.04	83.15	6107	780	3329	
S. E. of MEAN		468	1.64	0.22	0.64	442	47	91	
Sig. Diff. (19:1)		1,311	4.59	0.62	1.80	1247	133	254	
S. E. of MEAN in % of MEAN		5.19	4.74	1.69	0.77	7.24	6.07	2.73	
Calculated F. values		1.89	1.58	6.79	4.16	17.28	7.64	4.64	

Sig. F. 5% = 1.54 1% = 1.83

Table 5.

VARIETY TEST, TAYLORSVILLE, UTAH, 1960

Comparisons of Multigerm and Monogerm Parentage 1/

POLLINATORS		ACRE YIELD				PERCENT			
		GROSS SUGAR		TONS PER ACRE		SUGAR		PURITY	
		Multi. 211H3	Mono. 7121 MS	Multi. 211H3	Mono. 7121 MS	Multi. 211H3	Mono. 7121 MS	Multi. 211H3	Mono. 7121 MS
CT5A	Multigerm pollinator	9,130	8,662	36.0	33.7	12.7	12.8	81.9	82.6
CT5B	" "	9,866	10,022	37.0	37.8	13.3	13.3	83.7	83.3
CT5 RR	" "	9,005	8,981	34.3	34.8	13.1	12.9	83.9	82.5
CT9-O	" "	9,691	9,041	36.8	35.8	13.1	12.6	82.9	82.8
CT9A	" "	9,171	8,943	34.9	34.2	13.1	13.1	83.9	83.2
CT9.95	" "	9,709	9,235	33.1	36.3	13.2	13.4	84.1	84.3
General MEAN		9,260	9,146	35.4	35.4	13.1	13.0	83.4	83.1
131 mm	Monogerm pollinator	8,173	7,974	35.2	35.2	11.6	11.3	80.4	79.6
129 mm	" "	9,395	9,203	35.1	35.4	13.4	13.0	83.9	82.6
128 mm	" "	8,576	9,433	31.6	35.0	13.6	13.5	84.5	84.3
CT9 mm	" "	8,760	9,060	34.4	35.8	12.7	12.7	83.7	82.3
General MEAN		8,724	8,916	34.1	35.3	12.8	12.6	83.1	82.2

POLLINATORS		PARTS PER MILLION					
		Amino N		Na		K	
		211H3	7121 MS	211H3	7121 MS	211H3	7121 MS
CT5A	Multigerm pollinator	6201	5851	893	972	3319	3144
CT5B	" "	6200	6201	675	673	3216	3274
CT5 RR	" "	6618	6818	720	762	3336	3421
CT9-O	" "	6985	5580	783	957	3331	3292
CT9A	" "	6601	6200	767	979	3044	3342
CT9.95	" "	6584	5184	800	782	3247	3094
General MEAN		6532	5972	773	854	3249	3260
131 mm	Monogerm pollinator	6151	6985	967	1088	3769	3824
129 mm	" "	6385	6001	660	695	3331	3471
128 mm	" "	5434	5568	587	588	3252	3317
CT9 mm	" "	4818	5468	733	778	3311	3427
General MEAN		5696	6004	737	788	3415	3509

1/ Summary of data taken from Table 4.

Table 6.

VARIETY TEST, TAYLORSVILLE, UTAH, 1960

(3 replicated plots of each variety)

TEST 3

S. L. NUMBER	DESCRIPTION	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	PERCENT SUGAR	PERCENT PURITY	p.p.m. AMINO N	p.p.m. Na	p.p.m. K	BEETS 100' ROW
915	US 201B Virus 11, CT sel.	9,871	33.2	14.9	83.1	7766	463	3143	102
924	F_2b_2 of CT5A	9,968	37.0	13.4	84.3	4799	680	2886	117
926	CT5 aa X CT9	9,086	35.6	12.8	82.8	4966	686	3226	113
927	do.	8,059	30.2	13.3	82.6	5599	610	3346	98
928	do.	9,544	36.8	13.0	81.6	5899	533	3403	90
929	do.	7,660	29.7	13.0	83.0	4666	783	3253	88
931	CT5 aa X CT9A	10,429	37.4	14.0	84.6	5499	587	2100	112
933	CT5 aa X 7095 of CT9	9,486	35.6	13.3	82.0	6066	703	3290	106
9130	MS mm X Russian m'm'	10,948	43.0	12.7	81.4	4200	917	3550	110
9136	MS mm X SLC 130	9,624	36.1	13.3	82.7	4966	743	2956	107
9400	US 201B aa Sel. X Sibs	9,127	31.0	14.8	81.8	9299	470	3113	100
9401	do. X SP 57109-0 etc.	9,462	35.6	13.3	82.0	6366	736	3530	107
028	US 41 (adjacent strips)	9,617	36.8	13.1	81.2	7300	672	3552	102
General MEAN of all varieties		9,440	35.1	13.5	82.7	5953	659	3206	
S. E. of MEAN		465	1.56	0.31	0.98	656	45	140	
Sig. Diff. (19:1)		1,362	4.57	0.90	NS	1920	131	410	
S. E. of MEAN in % of MEAN		4.92	4.44	2.30		11.02	683	4.37	

TEST 4

(3 replicated plots of each variety)

S. L. NUMBER	DESCRIPTION	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	PERCENT SUGAR	PERCENT PURITY	p.p.m. AMINO N	p.p.m. Na	p.p.m. K	BEETS 100' ROW
627	(US 35/2 aa X Ovana) X CT8	7,681	29.1	13.2	84.7	4832	620	2873	109
628	do. X do.	8,658	35.5	12.2	81.4	5300	813	3140	109
632	do. X do.	7,742	30.1	12.9	83.8	5066	700	3120	112
633	do. X do.	8,082	32.3	12.5	82.7	5866	823	3310	113
308*	Ovana fodder beet	5,143	41.0	6.3	63.6	6132	1960	3790	114
028*	US 41 (adjacent strips)	6,062	24.8	12.4	82.0	5200	1030	2700	95
General MEAN of all varieties	(* = not included)	8,040	30.9	12.7	83.2	5266	740	3110	
S. E. of MEAN		409	2.35	0.35	1.16	490	83	98	
Sig. Diff. (19:1)		NS	NS	NS	NS	NS	NS	NS	

Table 7.

VARIETY TEST, TAYLORSVILLE, UTAH, 1960

TEST 5

(3 replicated plots of each variety)

S.L. NUMBER	DESCRIPTION	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	PERCENT SUGAR	PERCENT PURITY	p.p.m. AMINO N	p.p.m. Na	p.p.m. K	BEETS 100' ROW
7801	CT8 subline	6,555	23.9	13.7	83.6	5033	420	2853	94
7803	do.	6,173	21.0	14.7	85.3	3233	640	2589	100
7807	do.	7,481	26.2	14.2	84.2	6066	480	2913	102
7809	do.	6,009	20.4	14.8	84.3	5100	506	2716	87
7810	do.	5,226	17.5	14.8	85.3	4933	640	2793	70
7811	do.	6,706	21.4	14.4	83.1	6366	560	2646	99
7817	do.	6,725	26.3	13.0	81.2	6667	420	3140	93
7820	do.	6,402	23.2	13.9	82.6	6000	603	3113	86
7822	do.	7,968	27.1	14.7	82.8	7599	320	3006	107
7827	do.	5,348	17.7	15.0	85.8	3933	267	2480	85
7861	CT8 aa X Sibs	7,271	26.7	13.6	83.6	5999	470	3100	83
7862	do.	5,915	20.2	14.7	86.4	4233	413	2656	94
028	US 41 (adjacent strips)	8,658	35.2	12.3	78.6	6000	870	3360	111
028	US 41 " "	8,700	35.5	12.2	81.4	6450	828	3387	117
General MEAN of all varieties		6,483	22.6	14.3	84.0	5428	478	2834	
S. E. of MEAN		382	1.44	0.36	0.70	490	44	158	
Sig. Diff. (19:1)		1550	4.21	1.05	2.05	1434	127	NS	
S. E. of MEAN in % of MEAN		5.89	6.37	2.52	0.83	9.03	9.20		
9094	.95 of CT9	7,599	28.3	13.3	83.0	4966	703	3620	74
9095	7095 of CT9	7,278	27.3	13.4	84.1	5366	780	2713	106
(2 replicated plots of each variety)									
5070	CT7	6,085	19.6	15.7	84.6	6099	280	2430	104
5080	Line 289	5,863	18.3	16.0	83.4	10,060	357	2020	96
9096	CT9A	5,954	20.1	15.0	85.4	6000	680	2320	94
5090	CT9 subline	7,754	25.8	15.0	86.5	4000	510	2480	114

Table 8.

VARIETY TEST, TAYLORSVILLE, UTAH, 1960

(3 replicated plots of each variety)

TEST 6

S. L. NUMBER	DESCRIPTION	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	PERCENT SUGAR	PERCENT PURITY	p.p.m. AMINO N	p.p.m. Na	p.p.m. K	BEETS 100' ROW
9000	CT5 aa X sibs	9,093	31.0	14.7	86.3	4600	567	2486	110
9051	CT5A	6,950	28.1	12.3	80.5	6199	880	3040	110
9052	do.	6,742	29.6	11.4	80.3	5933	1103	3033	108
9053	82.501 of CT5	7,609	32.4	11.9	77.9	7333	957	3020	96
9054	82.507 of CT5	7,134	28.7	12.4	80.2	8799	706	2983	108
9055	82.521 of CT5A	6,993	25.7	13.5	84.6	5533	537	2636	104
9056	82.526 of CT5	7,169	25.2	14.2	83.1	8599	703	2406	111
9057	82.527 of CT5	5,772	21.9	13.2	81.8	7130	897	2580	99
9058	82.591 RR of CT5	6,839	26.3	13.0	80.8	8999	550	2793	105
9059	82.592 RR of CT5	6,433	22.8	14.1	83.2	6633	587	2796	104
028	US 41 (adjacent strips)	9,034	32.7	13.9	82.5	5833	897	3313	93
General MEAN of all varieties		7,074	27.2	13.1	81.9	6977	749	2777	
S. E. of MEAN		473	2.19	0.35	1.31	551	37	171	
Sig. Diff. (19:1)		1404	NS	1.04	3.89	1633	111	NS	
S. E. of MEAN in % of MEAN		6.69		2.67	1.60	7.90	4.94		

TEST 7

(3 replicated plots of each variety)

S. L. NUMBER	DESCRIPTION	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	PERCENT SUGAR	PERCENT PURITY	p.p.m. AMINO N	p.p.m. Na	p.p.m. K	BEETS 100' ROW
8000	CT5 aa X CT5	9,036	32.6	13.9	83.9	6799	446	3000	120
9452	CT5A aa X Sibs	8,350	33.6	12.4	81.8	5833	780	3323	118
9454	82.507 of CT5 aa X Sibs	8,330	32.1	13.0	80.3	9232	520	3003	122
9456	82.526 of CT5 aa X Sibs	8,039	28.3	14.2	82.4	8232	577	2640	109
9458	803 of CT5 aa X Sibs	9,497	35.8	13.3	82.2	7599	530	2886	116
9459	82.952 of CT5 aa X Sibs	8,308	28.3	14.7	83.6	6766	353	2760	109
028	US 41 (adjacent strips)	9,817	38.1	12.9	82.5	6066	747	3320	118
General MEAN of all varieties		8,594	31.8	13.6	82.4	7411	534	2935	
S. E. of MEAN		396	1.21	0.27	0.73	637	34	79	
Sig. Diff. (19:1)		NS	3.60	0.79	NS	1892	100	234	
S. E. of MEAN in % of MEAN			3.81	1.99		8.60	6.37	2.69	

Table 9.

VARIETY TEST, TAYLORSVILLE, UTAH, 1960

TEST 8

(3 replicated plots of each variety)

S.L. NUMBER	DESCRIPTION	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	PERCENT SUGAR	PERCENT PURITY	p.p.m. AMINO N	p.p.m. Na	p.p.m. K	BEETS 100' ROW
90.99	80.1 from Am. Crystal 56-407	7,082	27.2	13.0	80.8	6833	937	3813	91
90.100	80.8 " " 56-409	7,490	27.5	13.7	81.4	8800	800	3460	91
90.101	80.17 " " 55-410	7,817	29.2	13.4	80.8	8833	903	3747	98
90.102	80.23 " " 56-412	7,124	26.6	13.4	81.9	9366	807	3427	90
90.105	80.29 from Price US 75 sel.	8,161	30.7	13.3	81.5	6100	960	3853	91
90.106	80.57 " "	7,004	26.4	13.3	79.7	8400	963	3640	91
90.107	80.75 " "	7,901	29.4	13.5	81.7	7300	860	3623	93
90.108	80.78 " "	7,466	26.9	13.9	81.7	8533	810	3213	86
028	US 41 (adjacent strips)	7,332	28.0	13.1	81.3	6775	975	3272	94
General MEAN of all varieties		7,506	28.0	13.4	81.2	8021	880	3597	
S. E. of MEAN		374	1.38	0.29	0.32	3170	66	118	
Sig. Diff (19:1)		NS	NS	NS	NS	NS	NS	340	
S. E. of MEAN in % of MEAN								3.28	

TEST 9

(3 replicated plots of each variety)

S.L. NUMBER	DESCRIPTION	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	PERCENT SUGAR	PERCENT PURITY	p.p.m. AMINO N	p.p.m. Na	p.p.m. K	BEETS 100' ROW
9229	mm aa X mm CT sels.	8,908	33.5	13.2	82.8	5699	574	3256	119
9236	(117 X 125 aa) X CT9 mm	10,114	37.4	13.5	84.3	4666	543	3050	115
9237	122-16 aa X do.	10,420	36.4	13.9	84.9	4766	417	3240	118
9238	122-27 aa X do.	9,813	35.3	13.9	84.3	5266	417	3206	115
9239	122-19 aa X do.	8,856	34.7	12.8	81.8	5666	467	3623	111
028	US 41 (adjacent strips)	9,321	34.9	13.3	83.1	6133	577	3406	118
General MEAN of all varieties		9,624	35.5	13.5	83.6	5214	483	3275	
S. E. of MEAN		458	1.32	0.22	0.61	415	26	99	
Sig. Diff. (19:1)		NS	NS	0.70	2.00	NS	84	323	
S. E. of MEAN in % of MEAN				1.63	7.30		5.38	3.02	

Table 10

VARIETY TEST, TAYLORSVILLE, UTAH, 1960

TEST 10

(3 replicated plots of each variety)

S.L. NUMBER	DESCRIPTION	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	PERCENT SUGAR	PERCENT PURITY	p.p.m. AMINO N	p.p.m. Na	p.p.m. K	BEETS 100' ROW
9502	SLC 129	6,547	24.1	13.6	84.9	4000	460	3080	107
9503	SLC 128	7,030	26.1	13.4	85.4	4166	393	2579	104
9509	do.	5,970	22.9	12.9	82.8	4700	847	2716	107
9510	122-27	6,478	24.8	13.0	84.2	4800	540	3026	107
9511	122-19	7,685	30.2	12.5	82.3	5000	547	3370	105
9521	SLC 127 ++	6,937	27.7	12.5	83.2	3666	647	3430	100
9522	S_2 of .354+0	7,986	30.5	13.0	82.6	5266	777	3110	107
9523	S_2 of 86.50	5,537	25.2	10.9	76.0	7733	1153	3380	107
9526	S_2 of 86.98	5,923	24.5	12.1	80.1	5200	893	3356	106
9527	S_4 of 76.79	6,907	27.1	12.6	82.3	5400	820	3066	94
9528	S_4 of .248.1	7,988	31.1	12.8	82.6	5899	667	3540	106
9529	S_2 of .229	7,383	31.3	11.8	80.6	6333	733	3306	105
9530	do.	8,108	33.3	12.1	79.2	6866	820	3303	112
9531	S_2 of 86.6	6,501	25.9	12.6	81.2	5933	610	3206	102
9533	S_2 of 86.68	6,584	25.5	12.9	82.8	5966	573	3046	114
9534	S_2 of 86.89	7,629	26.7	14.4	85.5	5700	627	2556	120
9540	F_2b_1 of CT9	7,027	28.6	12.3	83.5	3650	640	3072	60
028	US 41 (adjacent plots)	8,700	35.5	12.2	81.4	6450	828	3387	117
General MEAN of all varieties		6,950	27.3	12.7	82.2	5414	694	3130	
S. E. of MEAN		656	2.08	0.29	0.90	362	61	110	
Sig. Diff. (19:1)		NS	6.00	0.83	2.61	1044	176	316	
S. E. of MEAN in % of MEAN			7.62	2.28	1.09	6.69	8.79	3.51	

Table 11.

VARIETY TEST, TAYLORSVILLE, UTAH, 1960

(3 replicated plots of each variety) New curly-top and sugar selections TEST 11

S.L. NUMBER	DESCRIPTION	ACRE YIELD GROSS SUGAR	ACRE YIELD TONS BEETS	PERCENT SUGAR	PERCENT PURITY	p.p.m. Amino N	p.p.m. Na	p.p.m. K	BEETS 100' ROW
9602		5,709	19.7	14.5	85.4	4400	520	2613	96
9603		5,901	22.2	13.1	82.9	4600	597	2943	91
9604		8,130	32.4	12.6	82.4	5300	650	3526	105
9605		6,678	23.9	13.7	83.1	4733	510	3426	89
9607		5,889	22.2	13.1	81.2	7699	567	3076	92
9608		7,013	29.4	11.9	80.3	5566	547	3400	89
9609		5,960	23.2	12.8	81.7	5633	683	3103	86
9610		6,688	29.6	11.3	79.3	7033	710	3680	103
9611		5,671	22.4	12.7	82.5	6000	550	3193	87
9612		6,483	28.6	11.3	81.5	5266	563	3603	94
9616		5,722	24.0	11.9	80.8	4866	637	3516	89
9618		7,853	29.2	13.4	84.5	5100	650	3066	91
9619		6,423	29.0	11.0	78.1	6266	927	3363	91
028	US 41 (adjacent strips)	7,220	30.2	11.9	80.6	5829	956	3503	102
028	US 41 " "	8,560	35.8	12.0	79.5	6043	842	3434	108
General MEAN of all varieties		6,471	25.8	12.6	81.8	5574	624	3270	
S. E. of MEAN		662	2.37	0.33	1.00	387	56	95	
Sig. Diff. (19:1)		1929	6.90	0.96	2.91	1127	162	276	
S. E. of MEAN in % of MEAN		10.23	9.19	2.62	1.22	6.94	8.97	2.91	

(1 replicated plot of each variety)

S.L. NUMBER	DESCRIPTION	GROSS SUGAR	TONS BEETS	SUGAR	PURITY	Amino N	Na	K	BEETS 100' ROW
9601		5,808	22.6	12.8	82.5	5200	660	3140	101
9606		5,897	23.4	12.6	81.8	4800	830	3650	82
9614		5,930	19.9	14.9	86.4	5100	430	2180	76
9615		8,203	29.4	14.0	84.4	5200	480	2720	100

EASY-BOLTING VARIETIES TESTED AT BRAWLEY, CALIFORNIA 1959-1960

By Kenyon D. Beatty and F. V. Owen
Statistical analyses by: George K. Ryser

Thirty-nine easy-bolting varieties and hybrids from the breeding program at Salt Lake City were included in the Brawley planting with the non-bolting hybrid US H2 included as a check. The seed was planted on pre-shaped single row beds 30 inches apart. Plots consisted of single rows 43 feet long with 2-foot alleys between plots. The beets were planted September 9 but the effective planting was on the first date of irrigation September 14, 1959.

Fertilizer applications: 200 pounds per acre of Triple Super Phosphate and 250 pounds per acre of Ammonium Nitrate in advance of planting, and 120 pounds per acre of nitrogen as a side-dressing after thinning. Half of the test received additional nitrogen (100# N units per acre) February 19. This additional N resulted in additional top growth but no appreciable difference in root yield. The average sugar percentage was reduced from 16.57 percent on the normal N to 15.66 percent on the high N.

Samples for sugar analyses were taken from only one block at each of the two N levels, from the ten varieties which were replicated a total of eight times. The sugar analyses were made by the Holly Sugar Corporation.

Stands were good. Only occasional skips were observed and these were measured. Where the total of these measurements for any one variety exceeded six feet, yields were corrected. These corrections were made on only two varieties, 943 and 9102. Performances of the varieties are given in Table 12.

Bolting observations were made March 12 when seven of the fastest bolting varieties showed seedstalks. On April 7 a careful count was made of all bolters. These bolting counts varied from 1 percent in the slowest bolting varieties, US H2 and SL 9113, to 78 percent in the fast-bolting hybrid SL 9121. The fastest bolting seedstalks were in full bloom when harvested April 13. Bolting did not appear to decrease root yield under the conditions of the experiment because SL 9121, which was one of the fastest bolters, produced the highest root yield.

TABLE 12 - VARIETY TEST, BRAWLEY, CALIFORNIA

2 randomized single-row plots on each of 2 fertility levels
10 varieties with (*) = four plots at each level

Planted Sept. 14, 1959
Harvested April 13, 1960

Variety (SL No.)	Description	AVERAGE Tons per acre	Sugar percent	Bolters percent 4/7/60	Beets per 100'	TONS PER ACRE High N	Normal N
USH2*	C 863H1 (check)	19.78	15.4	1	156	19.6	19.9
211H3*	US 22 MS	15.87	15.0	18	144	16.8	14.9
6103*	211H3 X CT5	18.92	15.6	56**	155	19.2	18.6
7106	do. X SLC 125 mm	19.98	15.6	13	154	19.4	20.5
931	CT5 rr aa X CT9A	16.31		62	141	16.3	14.5
932*	CT5 aa X do.	16.84	16.4	70	162	16.3	17.4
933	CT5 aa X CT9.95	16.15		61	146	17.1	15.2
942	CT5 mm X CT9 mm	17.64		69**	165	18.8	16.5
943*	CT5 Mm aa X do.	15.38	15.5	67**	158	13.7	17.0
952*	CT9 mm aa hyb. X CT5	19.04	15.8	30**	158	19.3	18.8
981	(117 X 125) mm aa X CT9.95	17.01		38	158	18.5	16.6
984	122-19 mm aa X do.	18.68		45	168	18.7	18.7
991	(117 X 125) mm aa X CT9A	19.52		57	148	19.5	19.5
994	122-19 mm aa X do.	17.77		57	165	17.1	18.4
9101*	211H3 X CT5A	20.16	15.7	76	154	20.5	19.9
9102*	do. X CT5 type O lines	18.48	15.8	50	136	18.1	18.9
9103*	do. X CT5 RR lines	18.48	15.8	11	155	18.4	18.5
9104	do. X CT9-O	17.60		36	156	18.8	16.4
9105	do. X CT9A	20.53		46	168	19.8	21.3
9106	do. X CT9.95	17.58		41	151	16.9	18.2
9111	do. X SLC 131 rr mm	18.81		36	173	18.9	18.7
9112	do. X SLC 129 mm	15.23		6	165	15.1	15.4
9113	do. X SLC 128 mm	16.18		1	169	17.9	14.6
9116	do. X SLC 130 rr mm	16.14		44	184	15.9	16.4
9117	do. X CT9 mm	19.64		29	172	18.8	20.5
9121	7121 MS mm X CT5A	23.23		78**	166	22.6	23.9
9123	do. X CT5 RR line	18.94		26	182	18.7	19.2
9124	do. X CT9-O	20.53		55**	169	19.4	21.7
9125	do. X CT9A	19.62		70	174	19.1	20.2
9126	do. X CT9.95	19.49		54	170	20.1	18.8
9130	do. X Russian mm	21.34		47	166	21.3	21.4
9131	do. X SLC 131 rr mm	17.54		41	153	19.2	15.8
9132	do. X SLC 129 mm	14.68		12	161	17.3	12.1
9133	do. X SLC 128 mm	14.55		3	166	15.4	13.7
9136	do. X SLC 130 rr mm	13.03		37	163	14.6	11.4
9137	do. X CT9 mm	17.44		45	157	18.1	16.8
9152	MS mm hyb. X SLC 131 rr mm	14.77		22	155	15.8	13.8
9157	do. X SLC 130 rr mm	11.24		29	168	10.8	11.7
9401	US 201B aa X SP 57109-O	16.84		58**	155	16.6	17.1
9451A	CT5A-O	8.62		64	142	9.5	7.7
General average		17.49	15.66	41	158	17.69	17.26

Diff. for sig. 5% point { Varieties "*" = 2.13
{ Others except 9451A = 2.77

* Replicated 4 times at each N level
** Extra early bolting with seedstalks evident March 12

An interpretation of varietal performance must take into consideration the conditions under which the plants were grown, but it is believed that at least some indication is given of overall combining ability for the various hybrid combinations. This information will be useful in choosing the most valuable parents for propagation purposes. This information obtained in April at Brawley is not obtained in the intermountain area until October.

Effect of multigerm versus monogerm parentage on yield

Table 13 shows results with twenty hybrids, ten with US 22 MS as the female parent and ten with the monogerm MS 7121 as the female parent. With multigerm pollinators, CT5A etc., a better average yield (20.36 tons per acre) was obtained with the monogerm MS female parentage than with the multigerm US 22 MS (18.87 tons per acre). With monogerm pollinators, SLC 128 etc., the situation was reversed. A better average yield was obtained (17.20 tons per acre) with US 22 MS as the female parent. When both parents were monogerm the yields were materially reduced (average = 15.44 tons per acre). The monogerm pollinator SLC 131 produced hybrids with luxuriant foliage but with only a moderately good yield of roots. The second backcross to CT9 (CT9 mm) produced an excellent hybrid when crossed with US 22 MS (yield = 19.64 tons per acre). The hybrid with the Russian monogerm SL 9130 (MS mm X "White Church" PI 254575) produced the second highest yield in the test.

Peculiarly curved beets from monogerm parentage

In all hybrids where both parents were monogerm there was a strong tendency for the roots to be curved--see pictures on separate page. This tendency was similar to observations of beets harvested at Brawley in 1959. Examination of individual roots pulled by hand from their original position revealed that the lower portion of each root curved toward the furrows as if influenced by moisture but some curved toward the north furrow, while others curved toward the south furrow. Curved roots were not seen in the multigerm varieties. The inbred CT5A with the very low root yield produced straight long roots without curves.

TABLE 13 - VARIETY TEST, BRAWLEY, CALIFORNIA 1/

Planted September 14, 1959
Harvested April 13, 1960

Pollinator	TONS PER ACRE ♀ Multigerm US 22 MS	TONS PER ACRE ♂ Monogerm 7121 MS	PERCENT BOLTERS 4/7/60 ♀ Multigerm US 22 MS	PERCENT BOLTERS 4/7/60 ♂ Monogerm 7121 MS
	Multigerm pollinators			
CT5A	20.16	23.23	76	78
CT5 RR	18.48	18.94	11	26
CT9-0	17.60	20.53	36	55
CT9A	20.53	19.62	46	70
CT9.95	17.58	19.49	41	54
Average	18.87	20.36	42	56
	Monogerm pollinators			
131 mm	18.81	17.54	36	41
129 mm	15.23	14.68	6	12
128 mm	16.18	14.55	1	3
130 mm	16.14	13.03	44	37
CT9 mm	19.64	17.44	23	28
Average	17.20	15.44	23	28

1/ Summary of data taken from Table 12.

MONOGERM CHARACTER ASSOCIATED WITH ROOT CURVATURE
BRAWLEY, CALIFORNIA, APRIL 1960

Hybrid (MS mm X SLC 128 mm), both parents monogerm
Average yield, 14.5 tons per acre; roots firmly curved

Hybrid (MS mm X CT5A), pollen parent multigerm
Average yield, 23.2 tons per acre; roots large and
straight.

(For discussion, see page 37)

SUMMARY OF UTAH, IDAHO, and BRAWLEY, CALIFORNIA TESTS 1/

At Brawley, California, with beets grown on single-bed ridges, hybrid combinations with both parents monogerm were lacking in vigor and developed conspicuously curved beets, possibly resulting from weaker roots which grew in the direction of soil moisture. Lack of vigor was observed on the same hybrid combinations under stress of curly top at Jerome, Idaho. At Taylorsville, Utah, near Salt Lake City, reduced yields were not always obtained where expected, probably due to an absence of stress of any kind and to a type of cultural care that made growing conditions very favorable. The over-all results emphasize the desirability of testing under conditions where a known type of stress is maintained to identify the lines and hybrids most likely to survive the various types of stress most commonly encountered by the American sugar-beet grower.

In order to compare monogerm hybrids with multigerm hybrids emphasis was placed on two sources of female parentage as shown in Tables 14 and 16.

Multigerm, SL 211H3 or US 22 MS. This strain has been used as a standard for several years. Its yield and sugar content are roughly equivalent to US 22/3. In certain combinations it has produced excellent hybrids and is regarded as a good tester for general combining ability.

Monogerm, SL 7121 MS mm. This line resulted from crossing the monogerm pollinator SLC 133 to a good but rather heterogenous curly-top-resistant MS monogerm strain.

Beets from the Jerome, Idaho, tests were taken to Nyssa, Oregon, where sugar determinations were made by the Amalgamated Sugar Company. Sodium, potassium, and nitrogen values were determined by Myron Stout from the Utah samples. Sodium and potassium were determined with a flame spectrophotometer. Amino nitrogen was determined by the Stanek-Pavlas method, using the spectrophotometer as an absorption instrument. The "Amino N" values reported are based on the concentration of glutamine necessary to produce the same color. True "Amino N" would be 0.097 times the values given. Sugar and purity (apparent purity) determinations were made by C. H. Smith. G. K. Ryser and Earl H. Ottley were responsible for all statistical analyses.

1/ Summary of field tests conducted by Utah-Idaho Sugar Company presented on page 40; and by the New Mexico Agricultural Experiment Station on page 42.

COMPARISON OF MONOGERM AND MULTIGERM PARENTAGE AT THREE LOCATIONS, 1960 [1]

Table 14.

POLLINATOR	TONS PER ACRE					
	BRAWLEY, CALIFORNIA		JEROME, IDAHO		TAYLORSVILLE, UTAH	
	Multigerm 211H3	Monogerm 7121 MS	Multigerm 211H3	Monogerm 7121 MS	Multigerm 211H3	Monogerm 7121 MS
			Multigerm pollinators			
CT5B			27.3	30.2	37.0	37.8
CT5A	20.2	23.2	27.4	28.0	36.0	33.7
CT5 RR	18.5	18.9	25.6	28.1	34.3	34.8
CT9-0	17.6	20.5	28.4	27.3	36.8	35.8
CT9A	20.5	19.6	25.9	26.8	34.9	34.2
CT9.95	17.6	19.5	26.3	26.4	33.1	36.3
General MEAN	18.9	20.3	26.8	27.8	35.4	35.4
			Monogerm pollinators			
131 mm	18.8	17.5	27.5	26.9	35.2	35.2
129 mm	15.2	14.7	26.0	25.1	35.1	35.4
128 mm	16.2	14.6	23.9	25.6	31.6	35.0
CT9 mm	19.6	17.4	28.0	25.2	34.4	35.8
General MEAN	17.4	16.0	26.4	25.7	34.1	35.3

1/ Summary of data from Tables 2, 4, and 13.
For additional information on comparisons, see Table 15.

RESULTS WITH ANNUAL LINES DERIVED FROM RUSSIAN MONOGERM BEETS

By F. V. Owen and G. K. Ryser

In last year's report we presented data which showed that when an annual monogerm beet derived from SLC 101 was crossed with Russian monogerm beets, the F_1 hybrids were essentially multigerm rather than monogerm. This indicated that a different type of inheritance might be involved; so to obtain basic information rapidly, a backcrossing operation was initiated to produce an annual equivalent of the Russian monogerm. After a second backcross, followed by selfing and rigid reselection, the objective was accomplished. Very uniform annual monogerm lines were produced. These annual monogerm lines, equivalent to the Russian monogerm (m'm') were then crossed with the annual monogerm clone (74536-9 BB mm aa) derived from SLC 101. Results were obtained for: (mm aa X mm), (mm aa X m'm') and m'm' selfed where: mm = monogerm derived from SLC 101, m'm' = monogerm derived from Russian monogerm beets (PI 263121 and PI 254575), aa = recessive for Mendelian male sterility and BB = homozygous dominant for annual. The following tabulation gives these results:

Parentage	Population number	Classification of offspring					Total plants
		Monogerm		Multigerm			
		Class A	Class B	Class C	Class D	Class E	
		%	%	%	%	%	
BB mm aa X mm	04701	50	50	0	0	0	10
do.	04702	66	33	0	0	0	15
BB mm aa X BB m'm'	04705	0	0	25	62	12	8
do.	04706	0	7	27	47	20	15
BB m'm' selfed	04711	65	30	5	0	0	20
do.	04712	64	36	0	0	0	11
do.	04713	100	0	0	0	0	29

Monogerm (A = all flowers single, no doubles
(B = mostly single but a few doubles on central axis

Multigerm (C = Some singles, many doubles and doubles on side branches
(D = Some singles plus doubles and triples
(E = Some quadruple clusters, or all doubles and triples.

SUGAR BEET SPECIAL VARIETY TEST- WEST JORDAN, UTAH
Conducted by the Utah-Idaho Sugar Company
1960

Cooperator:	Robert Jones
Experimental Design:	Randomized block with 6 replications of 25 varieties
Plot:	3 rows wide by 50 feet long
Planting Date:	April 6-8
Thinning Date:	May 23-26
First Irrigation:	June 14
Date Fertilizer Applied:	Before planting
Kind and Amount of Fertilizer:	450 pounds 24-20-0
Harvest Date:	October 24-26
History:	1956, 1957, and 1958, alfalfa; 1951, grain.

TABLE 15.

COMPARISONS OF MULTIGERM AND MONOGERM PARENTAGE
West Jordan, Utah - 1960

Summary of Data from Table 16, Page 41 1/

	Acre Yield				Sucrose	
	Gross Sugar		Roots			
Pollinator	211	7121	211	7121	211	7121
Multigerm	Pounds	Pounds	Tons	Tons	Percent	Percent
CT5 B	9,728	10,952	26.15	29.76	18.6	18.4
CT5 A	---	12,310	---	33.45	--	18.4
CT5 RR	10,321	---	28.20	---	18.3	--
CT9-0	10,156	9,784	27.30	27.33	18.6	17.9
CT9 A	10,386	11,478	28.85	31.36	18.0	18.3
CT9. 95	9,741	---	26.91	---	18.1	--
Monogerm						
SL 131 mm	10,870	---	30.88	---	17.6	--
SL 129 mm	9,800	9,471	26.63	25.46	18.4	18.6
SL 128 mm	11,040	---	28.75	---	19.2	--
CT9 mm	9,936	11,034	27.91	30.48	17.8	18.1
Sig.Diff. (Odds 19:1)	1,382		3.62		0.7	

1/ For other comparisons of pollinators, see Tables 3 and 5 on pages 22 and 25, respectively.

Table 16.

SPECIAL VARIETY TEST - WEST JORDAN, UTAH - 1960
(6 Replicated Plots of Each Variety)

Variety		Description	Acre Yield Gross Sugar	Acre Yield Tons Beets	Percent Sucrose
1.	9121	7121 MSmm x CT5 A	12310	33.45	18.4
2.	9125	7121 MSmm x CT9 A	11478	31.36	18.3
3.	9113	211 H_3 x SL 128mm	11040	28.75	19.2
4.	9137	7121 MSmm x CT9mm	11034	30.48	18.1
5.	SL 994	122 - 19mmaa x CT9 A	11000	29.73	18.5
6.	9140	7121 MSmm x 803 of CT5 B	10952	29.76	18.4
7.	9111	211 H_3 x SL 131rrmm	10870	30.88	17.6
8.	9105	211 H_3 x CT9 A	10386	28.85	18.0
9.	SL 991	(117 x 125)mmaa x CT9 A	10384	28.53	18.2
10.	SL 931	CT5 rraa x CT9 A	10360	27.70	18.7
11.	9103	211 H_3 x CT5 RR line	10321	28.20	18.3
12.	9116	211 H_3 x SL 130 rrmm	10163	27.03	18.8
13.	9104	211 H_3 x CT9-0	10156	27.30	18.6
14.	9102	211 H_3 x CT5 Type 0-rr lines	10062	26.76	18.8
15.	9117	211 H_3 x CT9mm	9936	27.91	17.8
16.	9112	211 H_3 x SL 129mm	9800	26.63	18.4
17.	9124	7121 MSmm x CT9-0	9784	27.33	17.9
18.	N-110	117 MS x U&I 110	9757	26.23	18.6
19.	9106	211 H_3 x CT9. 95	9741	26.91	18.1
20.	9100	211 H_3 x 803 of CT5 Nelson	9728	26.15	18.6
21.	R-110	122 MS x (824aa x CT5) x CT9	9595	26.36	18.2
22.	SL 943	CT5 Mmaa x CT9mm	9565	26.28	18.2
23.	9132	7121 MSmm x SL 129mm	9471	25.46	18.6
24.	U&I 110	Sugar Sel 202	9385	25.23	18.6
25.	R - 110	122 MS x U&I 110	8678	23.33	18.6
General Mean of all Varieties			10238	27.86	18.4
S. E. of Mean			489	1.28	.249
Sig. Diff. (19:1)			1382	3.62	.704
S. E. of Mean in % of Mean			4.78	4.59	1.35

(Odds 19:1 = $2\sqrt{2}$ x Standard Error of Mean. NS = F value not significant.)

VARIANCE TABLE

Variation due to	Degrees of Freedom	Mean Squares Gross Sugar lbs.	Mean Squares Tons Beets	Mean Squares Percent Sucrose
Between Varieties	24		2 .34	.776
Between Blocks	5		26.77	2.81
Remainder (Error)	120		9.85	.371
Total	149		2.98**	2.09**

Calculated F Value
* Exceeds the 5% point of significance (F = 1.60)
** Exceeds the 1% point of significance (F = 1.94)

Variety Test, University Park, New Mexico, 1960
In cooperation with the New Mexico Agricultural Experiment Station
(By J. C. Overpeck)

The annual field test in cooperation with the New Mexico Agricultural Experiment Station gave higher than average yields obtained in recent years. The varieties were planted on two different dates, March 5 and April 5. March planting out-yielded April planting in all but one of the eight varieties, which were replicated four to six times at each date of planting.

Curly top was little in evidence in this test, which undoubtedly accounts for the relatively high yields. However, curly top was quite destructive in a group of plantings of basic breeding stocks in another location about 300 yards away.

Cercospora leaf spot was very prevalent in the variety test in September and October but was not conspicuous at harvest time, December 1. It was noticeable that the three highest yields from each date of planting were from varieties that ranked highest in leaf spot resistance.

Table 17.

Sugar Beet Variety Test, University Park, New Mexico, 1960
In Cooperation with the New Mexico Agricultural Experiment Station
Harvested Nov. 29, 30, and Dec. 1

Variety	Tons Beets per A		Weight per Root		Roots per 100' row	
	Mar. 5 Planting	Apr. 5 Planting	Mar. 5 Planting	Apr. 5 Planting	Mar. 5 Planting	Apr. 5 Planting
SP 586-0	25.1	22.6	2.3	2.3	93	62
USH2	30.7	30.1	2.4	2.1	110	121
943	32.4	24.9	2.5	2.2	108	95
9113	29.7	28.0	2.3	2.0	108	119
9117	30.6	28.0	2.4	2.1	106	114
9229	24.2	23.3	2.2	1.9	93	104
F55-92	28.3	25.4	2.3	2.0	105	109
SP581-0	30.8	25.4	2.5	2.2	106	76
Sig. Diff. (Odds 19:1)	5.4	3.6				
Average	29.0	26.0				

Six replications in each date of planting except SP586-0 and SP581-0 with four replications only in April 5 planting.

Cercospora leaf spot rather severe as observed in September and October, but not conspicuous at harvest time. Curly top very little in evidence.

PART III

PHYSIOLOGICAL INVESTIGATIONS

on

NUTRITION AND ENVIRONMENTAL FACTORS AFFECTING QUALITY

FOUNDATION PROJECT 15

Myron Stout

REDISTRIBUTION OF NITRATE IN THE SOIL AND ITS RELATION TO SUGAR BEET CULTURE

By Myron Stout

Studies on the evaporative redistribution of nitrate in soil under irrigation and its effect on nitrate nutrition of sugar beets were continued in 1960. The principal objectives are: 1. to obtain basic information on the patterns of movement and nitrate concentration gradients under irrigation, rainfall and high rates of evaporation. 2. to study practical ways to achieve better control of nitrogen uptake throughout the growing season as a means of improving yield and quality of the roots at harvest. An abundant supply of nitrate is desirable early in the season to stimulate early growth and yield. Nitrate uptake should be limited late in the season, to prevent excessive leaf growth and to insure high quality.

Vertical and lateral movement of nitrate was studied on the same plot of sandy loam soil reported on in 1959. (See table 1, page 40, of the 1959 report).

Irrigations occurred at about 5-day intervals unless rainfall made furrow irrigations unnecessary. Irrigation furrows were rather shallow and were 40 inches apart. There was no flooding in the sampled areas. Climatological and soil analysis data are presented in Table 1. Sugar beet seed was planted and first irrigated August 10. By August 12 considerable lateral as well as vertical movement had occurred.

A rather heavy rainfall of 0.66 inches, during a short period, occurred August 22. The rapid rate of rainfall reduced the surface nitrate concentrations but not nearly so greatly as the more moderate rate of rain on September 13, 14 and 15 in 1959, or October 8 to 12, 1960 (compare Table 2, page 48 this report).

The plots were fertilized with an undetermined amount of ammonium nitrate and irrigated August 28. The fertilizer was placed below the surface in the bottom of the furrows. It is evident from the samples taken August 30 and September 12 that sample location 5 received less nitrate than location 1.

TABLE 1 - Nitrate Redistribution Studies, Holden plot 1960
Vertical and lateral movement of nitrate in relation to irrigation, rainfall, and evaporation. Fine sandy-loam soil, 40-inch double beds

DATE	RAIN[1/] In.	EVAP.[2/] In.	DEPTH In.	Nitrate- N. across bed (40 inches) Position of samples on bed: 1	2	3	4	5
April	0.40	7.42						
May	1.09	10.34						
June	0.30	13.65						
July	0.10	16.16						
Aug.	0.66	13.11						
Sept.	0.70	9.76						
Oct.	1.23	5.37						
Total	4.48	75.81						
Aug. 12			0-1/2	1	370	230	210	1
			1/2-6	1	9	12	6	1
			6-12	4	6	10	4	3
			12-24	11	10	13	18	15
			24-36	16	11	11	17	13
Aug. 19			0-1/2	3	340	700	510	3
			1/2-6	1	7	11	2	1
			6-12	3	5	8	3	2
			12-24	11	13	18	18	11
			24-36	15	13	18	21	10
Aug. 22	0.66							
Aug. 23			0-1/2	1	43	108	50	1
			1/2-6	2	38	90	12	1
			6-12	2	14	15	4	1
			12-24	11	18	26	16	7
			24-36	4	19	20	16	19
Aug. 28	Fertilized in bottom of furrow with NH_4NO_3+ irrigation							
Aug. 30			0-1/2	5	368	464	504	3
			1/2-6	32	7	37	4	11
			6-12	27	10	11	5	5
			12-24	19	17	20	18	6
			24-36	13	14	16	15	10
Sept. 1	0.13		0-1/2	21	350	1210	470	6
3	0.39		1/2-6	12	9	28	2	4
6	0.01		6-12	32	19	22	4	10
12	0.04		12-24	20	24	18	14	12
			24-36	16	12	17	17	14

1/ Rainfall, Midvale, Utah
2/ Evaporation Morton Salt Company Plant

FIGURE 1. Sugar beets on the Joseph J. Schmidt farm, West Jordan, Utah, October 17, 1960. Beets in foreground have been harvested. The cross strip received a heavy application of ammonium nitrate in July. At harvest there was more nitrate in the surface of the area where the beets were deficient but it was in the dry soil and unavailable to the plants.

The study was discontinued after September 12 when the surface soil was accidentally disturbed by cultivation. The data obtained up to September 12 corroborate that obtained in 1959. The precipitation was much lower and the evaporation rate was higher in 1960 than in 1959.

NITRATE REDISTRIBUTION IN A COMMERCIAL SUGAR BEET FIELD

J. J. Schmidt farm, West Jordan, Utah, 1960

An extreme case of evaporative redistribution of nitrate in part of a 10-acre field of beets was observed in the fall of 1960. The field had been in grain in 1959 and a fairly heavy cover of straw and stubble was plowed under in the fall; then 135 pounds of nitrogen per acre was applied as anhydrous ammonia. Phosphate was also added in the fall. An early planting of sugar beets was frozen and the field was replanted April 22. Although there was a good stand of sugar beets, they grew very slowly and were obviously very deficient in nitrogen, as shown by tests with diphenylamine. Irrigations were applied in alternate-row furrows. The farmer, Mr. Joseph J. Schmidt, made a heavy surface application of ammonium nitrate in three strips crosswise to the rows about July 2. The cross-strips were about 10 feet wide and 200 feet long. The response to the ammonium nitrate was very striking and sharply delineated, as shown in Figure 1, photographed October 17 during harvest. The foliage of the beets in the cross-strips was more than knee high and very dark green in color, while the foliage of the adjacent beets did not cover more than half the 22-inch rows, was only about ankle high, and the beets appeared to be extremely deficient in nitrogen.

In the evening of October 8, soil samples were taken to a depth of two feet in the furrows and between furrows in both the cross-strips and the nitrogen-deficient beets. The soil was quite dry. A light but rather steady rainfall amounting to a total of 1.23 inches occurred October 8, 9, 10, 11 and 12. The same areas were resampled October 12. In addition to the soil profile samples, four surface samples were taken between furrows in the centers of beds where the

deficient beets were located, and five surface samples were taken where the heavy foliage had protected the surface soil from the rain. These latter samples were not taken midway between furrows but usually closer to the beet rows where the foliar cover was best.

The data in Table 2 show that before the rain there was more nitrate in the surface of the relatively bare soil where the deficient beets were than in the surface where the beets with heavy foliage were located. The 1260 p.p.m. of nitrate nitrogen observed in the surface soil where the deficient beets were located is equivalent to about 286 pounds N per acre--in the top half inch of soil. The rain leached all but 4 p.p.m. out of the top half inch of relatively unprotected soil. Where the heavy foliage covered the soil there was only 610 p.p.m. of nitrate nitrogen in the top half inch before the rain, and apparently the foliage prevented leaching much of it to lower levels. In areas where the soil was well protected by the foliage the soil was still relatively dry and a saline deposit could be observed. Five surface samples showed an average of 372 p.p.m. in these areas. The observations concerning the protective action of good foliar cover in preventing rain from leaching surface nitrate to lower levels is similar to that observed on two farms in the same general area in 1959.

IRRIGATION AND DRAINAGE WATER STUDIES

Leaching of nitrate from the soil has probably been overemphasized as a factor in nitrate depletion of our arid soils. In some instances of sandy soils or overirrigation, leaching is probably a very important factor; however, where good water-conserving practices are used, irrigation water may actually supply more nitrate than the drainage water removes.

In arid climates the high rate of surface evaporation increases our salinity problem in two ways. The salt content of our irrigation waters is high to begin with, due to evaporative concentration in the surface soil of our water sheds, and the high evapo-transpiration rate after the water is applied to farmland

TABLE 2 - Nitrate Nitrogen in Soil Profile
Joseph J. Schmidt farm, West Jordan, Utah.
Samples before and after a prolonged light rain of 1.23 inches[1/]
(Sampled October 8 and October 12, 1960)

	Between furrows		In furrows	
	Before rain p.p.m.	After rain p.p.m.	Before rain p.p.m.	After rain p.p.m.
SMALL FOLIAGE (nitrogen-deficient plants)				
Depth				
0-1/2	1260	4	2	0
1/2-6	1	65	1	1
6-12	0	1	0	0
12-24	1	1	0	1
LARGE FOLIAGE (dark green strips)				
0-1/2	610	48	28	1
1/2-6	1	104	1	1
6-12	1	1	0	1
12-24	2	1	0	1

SURFACE (0-1/2 inch) SAMPLES BETWEEN FURROWS AFTER RAIN

	After rain Small foliage p.p.m.	After rain Dark-green foliage p.p.m.
1	3	330
2	2	430
3	8	450
4	3	400
		250
Average	4	372

1/ Rainfall Midvale, Utah, October 8-12 = 1.23 inches

further concentrates the salts. Periodic leaching in some areas is necessary to maintain productivity. We have excellent information available on salinity distribution under irrigated agriculture. Since nitrate salts are even more soluble and form no insoluble compounds with soils at normal temperatures, they may be expected to move more freely with water in the soil. Since subsurface soils are usually low in nitrate, it seemed reasonable to expect drainage water leaching through them to be relatively low.

Samples were taken periodically from drains and the canal waters used to irrigate the soils in the same areas. Irrigation water 1 (Figure 2) contains considerable runoff and waste water. Irrigation water 2 (Figure 3) is from Utah Lake. The data in Figure 2 show a relatively high nitrate content in the South Jordan Canal water. The nitrate content declined from May to July, then increased. This was also apparent in the Jordan River water. The increases in nitrate content late in the season may be due in part at least to surface runoff following rainfall. The data in Figure 3 show a rather steady decline of nitrate in the water from Utah Lake. This decline may be due to increased uptake by water plants and algae. Drain 2 (Figure 3) declined rapidly in volume and nitrate content. It is very probable that the absorption of nitrate by water plants was the predominating factor responsible for the decline in nitrate content.

The percentage of irrigation water that reaches the drains is probably relatively low in arid climates but it is also subject to great variation. The data in Figure 2 indicate that the irrigation water supplied more nitrate than it removed from the soil. The data in Figure 3 (drain 3) probably removed nitrate from the soil. The study does indicate that irrigation waste water and surface runoff water are relatively high in nitrate content and that leaching of nitrate from our arid soils under normal water-conserving practices has probably been overemphasized. Samples of water from drains having a low volume and high plant population are unreliable.

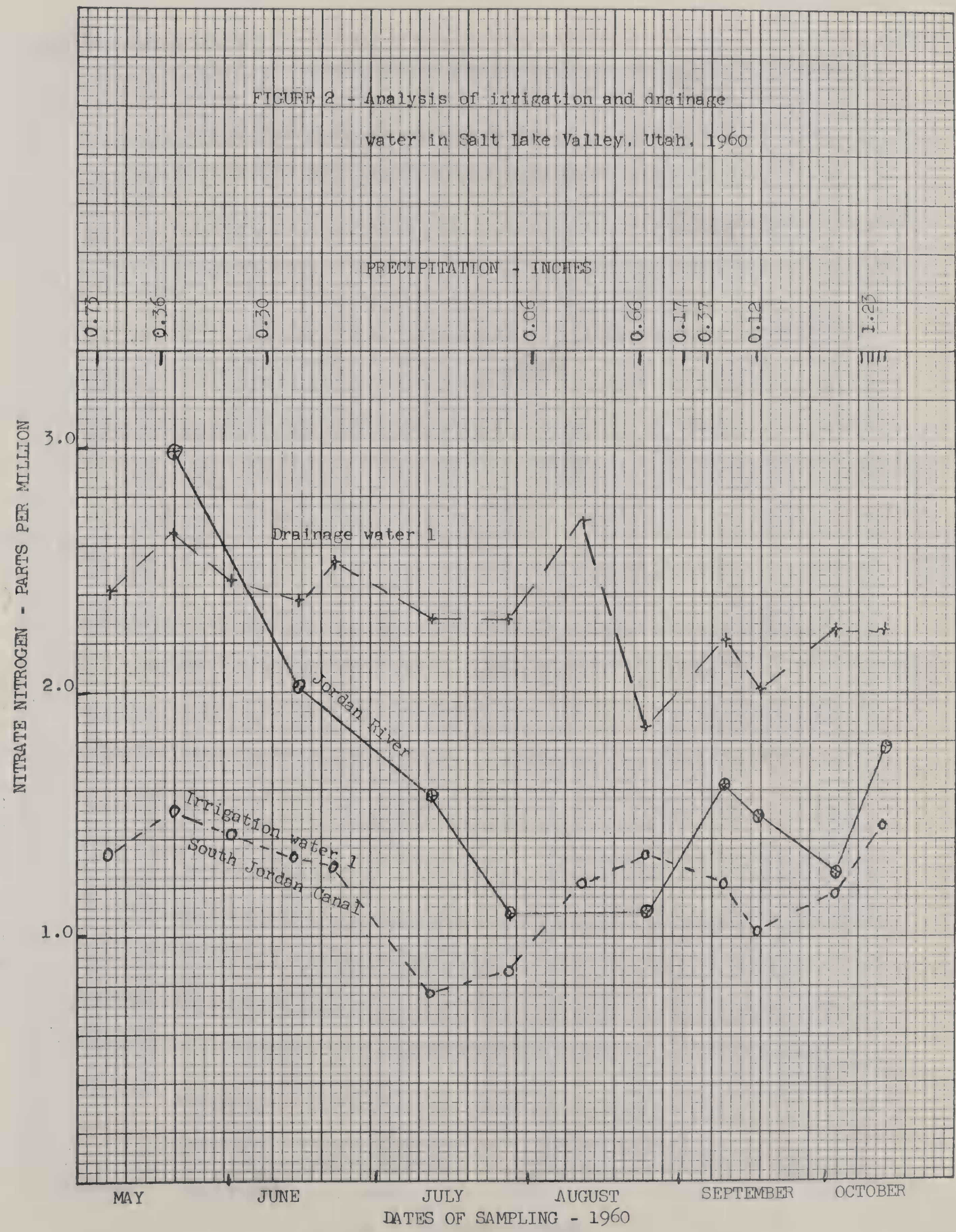
FIGURE 2 - Analysis of irrigation and drainage water in Salt Lake Valley, Utah, 1960
PRECIPITATION - INCHES
0.75
0.36
0.30
0.06
0.66
0.17
0.37
0.12
1.23
NITRATE NITROGEN - PARTS PER MILLION
3.0
2.0
1.0
Drainage water 1
Jordan River
Irrigation water 1
South Jordan Canal
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
DATES OF SAMPLING - 1960

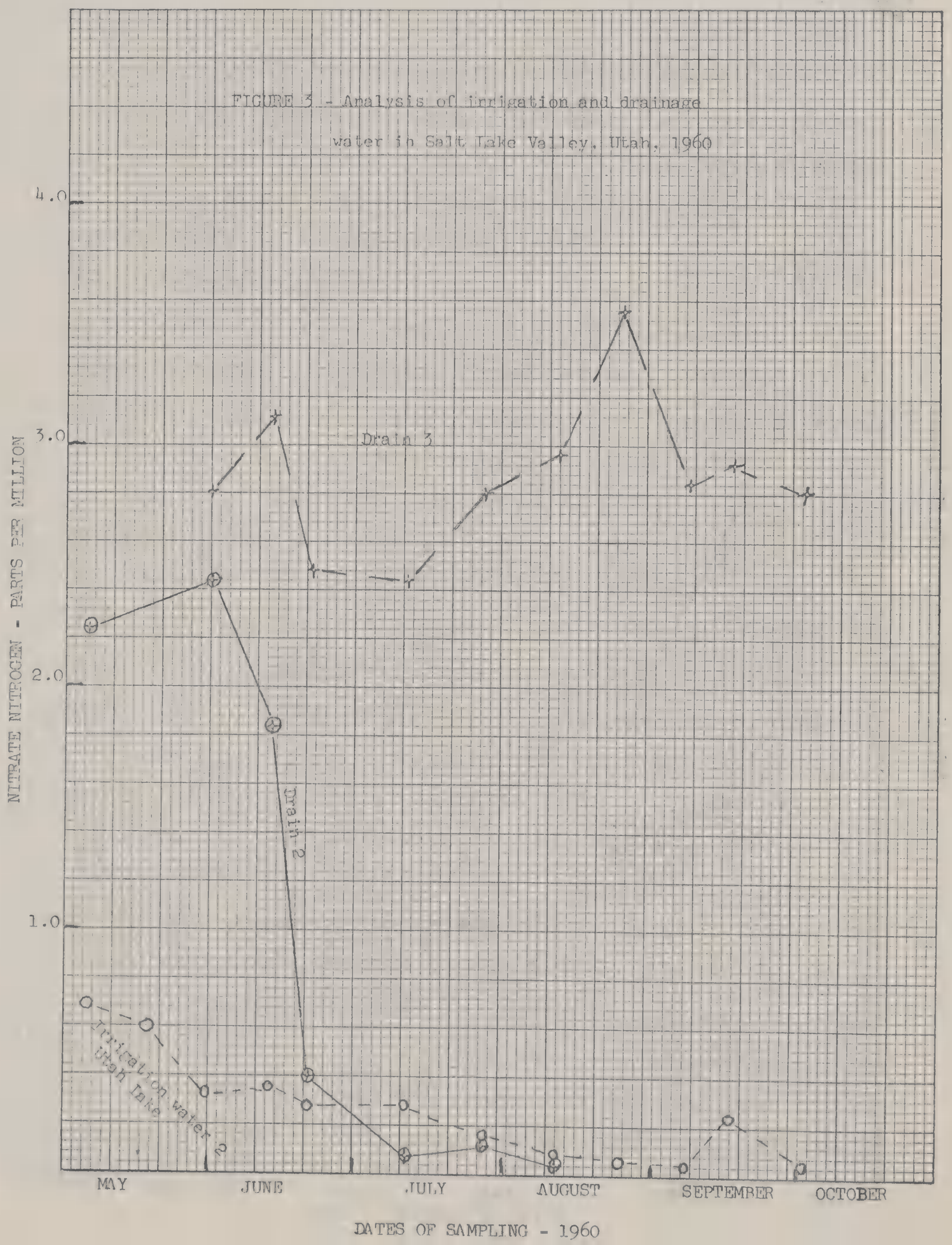
FIGURE 3 - Analysis of irrigation and drainage
water in Salt Lake Valley, Utah, 1960
NITRATE NITROGEN - PARTS PER MILLION
4.0
3.0
2.0
1.0
Drain 3
Drain 2
Irrigation water 2
Utah Lake
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
DATES OF SAMPLING - 1960

1960 FIELD STUDIES IN COOPERATION WITH THE UTAH-IDAHO SUGAR COMPANY

Nitrate analyses were made during the summer of 1960 on a large number of soil samples taken in Utah and Washington from tests conducted by the Utah-Idaho Sugar Company in relation to cultural and irrigation practices that may influence the distribution of nitrate in the soil profile and thereby affect the amount of nitrate taken up by the sugar beets during the growing season. These tests involve depth of furrows under both furrow and overhead irrigation. They also cover a wide variation in the total amounts of nitrate as well as high and low concentration gradients in the soil profile. The nitrate nitrogen content of the samples has varied from 0 to 3400 p.p.m. Overhead irrigation greatly reduced surface nitrate concentration. Yield, sugar, amino nitrogen, sodium, and potassium content of the roots are to be determined.

When the tests are complete, the data should give us valuable information leading to the development of methods for the control of nitrate uptake in the sugar beet under a rather wide range of environmental conditions.

The studies made thus far have shown an extremely wide range in concentration and distribution of nitrate in soils under varying environmental conditions. The increased use of chemical fertilizers and the reduced use of manure and crop residues, which release nitrate more slowly in the soil, will accentuate the redistribution. If we are to achieve maximum production and high quality, the natural forces that result in erratic behavior in relation to nitrate nutrition should be evaluated in the different areas. Practical means of nutritional management may then be developed. Probably the best methods for solving the problem will be as variable as the environmental conditions in the various areas.

PART IV

POLYPLOIDY IN RELATION TO ROOT YIELD AND SUCROSE PERCENTAGE

- -

INTERSPECIFIC HYBRIDIZATION

Foundation Project 11

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POLYPLOIDY IN SUGAR BEETS

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1. COMBINING ABILITY IN DIPLOID, TRIPLOID AND TETRAPLOID MONOGERM MALE-STERILE HYBRIDS.

The high proportion of heterozygotes in sugar beet populations favoring vigor and high yield makes heterosis of hybridizations one of the most important methods in sugar beet breeding. In the reported experiment a comparative effectiveness of combining ability in diploid, triploid, and tetraploid hybrids was studied.

Materials and Methods

Combining ability was studied in an inbred line and in the following diploid and tetraploid populations:

(a) SLC 15 monogerm self-sterile curly-top-resistant strain.

(b) US 35/2 multigerm curly-top-resistant variety

(c) US 104 multigerm curly-top-resistant variety

(d) US 401 multigerm leaf-spot-resistant variety

(e) SLC 91 monogerm self-fertile inbred

(f) Diploid and tetraploid male-sterile equivalents of the inbred line SLC 91 were used for obtaining diploid, triploid and tetraploid hybrids with the 4 above-mentioned varietal populations (Table 1).

All tetraploid strains were developed by Helen Savitsky after propagation of 70 or 80 C_1 plants derived from about the same number of C_0 4n plants after colchicine treatment. The genetic structure of these tetraploid populations was in this way close to the genetic structure of their diploid ancestors.

Hybridization of male-sterile monogerm strain SLC 91 with diploid and tetraploid populations (for instance with US 104, US 401, etc.) was conducted in a separate isolation for each variety. Thus, each variety had one isolation for a diploid and a second isolation for a tetraploid pollinator. In every isolation a pollinator was planted beside a diploid and tetraploid male-sterile of monogerm strain SLC 91. Seed was harvested separately from all these strains. Male-

Table 1.--Origin of populations and code number of entries.

CODE NUMBER	NUMBER OF CHROMOSOMES	POPULATIONS
31	18	US 104 multigerm
32	36	Tetraploid US 104 multigerm
33	18	SLC 91 monogerm (self-fertile inbred)
34	36	Tetraploid SLC 91 monogerm (self-fertile inbred)
35	27	2n MS 91 monogerm X 4n US 104
36	36	4n MS 91 monogerm X 4n US 104
37	18	2n MS 91 monogerm X 2n US 104
38	27	4n MS 91 monogerm X 2n US 104
39	27	4n MS 91 monogerm X 2n 91
40	27	2n MS 91 monogerm X 4n 91
41	18	US 401 multigerm
42	36	Tetraploid US 401 multigerm
43	27	2n MS 91 X 4n US 401
44	27	4n MS 91 X 2n US 401
45	18	2n MS 91 X 2n US 401
46	36	4n MS 91 X 4n US 401
47	18	US 35/2 multigerm
48	36	Tetraploid US 35/2 multigerm
49	27	2n MS 91 X 4n US 35/2
50	36	4n MS 91 X 4n US 35/2
51	18	2n MS 91 X 2n US 35/2
52	27	4n MS 91 X 2n US 35/2
53	18	Monogerm self-sterile SLC 15
54	36	Tetraploid monogerm self-sterile SLC 15
55	27	2n MS 91 X 4n monogerm self-sterile 15
56	27	4n MS 91 X 2n monogerm self-sterile 15
57	18	2n MS 91 X 2n monogerm self-sterile 15
58	36	4n MS 91 X 4n monogerm self-sterile 15

sterile plants have been checked several times for male-sterility.

Because pollinator and male-sterile 2n and 4n strains grew together in the same isolation, all nongenetic sources of variation which could arise from seed development in different environments were eliminated.

Four kinds of hybrids were obtained from hybridization of the male-sterile strain with each variety. The following entries have been tested for percent sucrose and yield in hybrids with each variety, as indicated here for the hybrids with the population SLC 15:

(1) SLC 15 (pollinator), a diploid monogerm self-sterile population

(2) SLC 15 (pollinator), a tetraploid monogerm population

(3) Triploid: 2n male-sterile 91 X 4n SLC 15

(4) Triploid: 4n male-sterile 91 X 2n SLC 15

(5) Diploid F_1 hybrid: 2n male-sterile 91 X 2n SLC 15

(6) Tetraploid F_1 hybrid: 4n male-sterile 91 X 4n SLC 15

(7) Diploid monogerm inbred line SLC 91

(8) Tetraploid monogerm inbred line SLC 91

Experimental Design and Analysis of Variance

Degrees of freedom, sum of squares, and sources of variation in analysis of variance are shown in Table 2.

The total number of entries in the experiment equalled 28, planted in 12 replications in a randomized complete block design. Table 2 shows highly significant differences for populations in both characters because the F ratio for percent sucrose equalled 2.76 and for tonnage 11.56, while tabulated F at the 5-percent point level equalled 1.71 and at the 1-percent level, 2.16.

Experimental Results

Yield and percent sucrose in diploid and tetraploid parental strains. The effect of chromosome doubling for percent sucrose and yield was different in different populations (Table 3).

Two populations (US 401 and US 104) showed a significant tendency to increase

Table 2.--Mean squares, degrees of freedom and sources of variation in analysis of variance for percent sucrose and weight of roots.

Sources of variation	Degrees freedom	Roots (pounds)					Percent sucrose				
		Sum of squares	Mean squares	Variance ratio	F 005	F 001	Sum of squares	Mean square	Variance ratio	F 005	F 001
Total sum of squares	335	54,301	---	---	--	--	272.4119	---	---	--	--
Between blocks	11	3,143	285.7273	3.4023	2.42	3.66	8.2744	1.6613	2.4279	2.42	3.66
Between populations	27	26,216	970.9630	11.5619	1.71	2.16	50.9160	1.8858	2.7560	1.71	2.16
Residual (error)	297	24,942	83.9798	---	--	--	203.1215	0.6842	---	--	--

Table 3.--Diploid and tetraploid colchicine-induced populations: monogerm SLC 91 and SLC 15, and multigerm US 35/2, US 104, and US 401.

	Tons roots			Percent sucrose		
	Diploid	Tetraploid	Difference	Diploid	Tetraploid	Difference
SLC 91 monogerm	22.0876	23.0771	+ 0.9895	13.3750	14.0467	+ 0.6717
SLC 15 monogerm self-sterile	27.5501	27.1146	-0.4355	13.3200	13.8750	+ 0.5550
US 35/2	29.3709	29.5292	+ 0.1583	13.6750	13.2167	-0.4583
US 104	29.0146	33.6855	+ 4.6709	12.9200	12.9800	+0.0600
US 401	29.7272	35.2688	+ 5.5416	12.4500	13.0800	+0.6300
msd at 5% point			3.4989			0.6649
lsd at 1% point			4.6078			0.8756

the yield when turned into tetraploids. Tetraploid US 401 exceeded significantly in weight of root its diploid ancestor at the parallel increase in percent sucrose.

Tetraploid US 35/2 showed a very little increase in yield and a decrease in percent sucrose. Both these deviations in the variety US 35/2 were not significant.

The self-sterile tetraploid population monogerm SLC 15, as well as the self-fertile tetraploid SLC 91 monogerm, increased in percent sucrose in comparison with the diploid ancestors, being statistically significant for SLC 91.

Because of changes in percent sucrose and weight of root caused by chromosome doubling, tetraploid populations differed from each other, other than their original diploid populations.

The yield in diploid as well as in tetraploid inbred SLC 91 was significantly lower than the yield in all multigerm populations at diploid and at tetraploid levels. Diploid monogerm self-sterile SLC 15 did not differ significantly in yield from all diploid multigerm varieties. Tetraploid population US 401 exceeded significantly in yield the diploid and also the tetraploid monogerm self-sterile population SLC 15.

On the other hand, only diploid US 35/2 exceeded in percent sucrose US 401 and US 104 populations. However, at the tetraploid level the difference in percent sucrose between these varieties was not significant.

Only the tetraploid SLC 15 population, as well as the SLC 91 inbred line, showed a significant excess in percent sucrose in comparison with the diploid and the tetraploid US 104 and US 401.

Combining Ability in Diploids

The diploid populations studied could be distributed into 2 groups. The first group included multigerm varieties US 35/2, US 104, and US 401. From these varieties F_1 hybrids were produced by crosses with male-sterile SLC 91, which significantly exceeded in yield the inbred line SLC 91. The excess in yield equalled 7 or 10 tons of beets. The weight of roots in these F_1 hybrids was also higher than in the original multigerm populations (US 35/2, or US 104), but this excess was never significant. On the other hand, F_1 hybrids with US 35/2 or with US 104 exceeded the

yield of the calculated middle parent $\frac{(P_1 + P_2)}{2}$ more than by 6 tons. None of these F1 diploid hybrids exceeded significantly in percent sucrose their parental varieties (Table 4).

Thus, hybridization of the monogerm line SLC 91 made it possible to obtain monogerm male-sterile hybrids with the same or a little higher yield and sucrose than in the original multigerm varieties.

The second group consisted of F_1 hybrids between the male-sterile strain SLC 91 and monogerm self-sterile population SLC 15. In comparison with the diploid self-sterile population SLC 15, the F_1 hybrid significantly decreased the yield of roots. The yield in the F_1 generation equalled the yield of the middle parent $\frac{(P_1 + P_2}{2}$. At the same time, the percent sucrose was significantly higher in F_1 hybrids.

These data indicate heterosis in percent sucrose, but there was no positive heterosis in yield (Table 4). It is difficult to expect to obtain heterosis in weight of root in this case, because monogerm strain SLC 91 and monogerm population SLC 15 are to some extent related stocks.

Combining Ability in Tetraploids

Populations which differed in combining ability at the diploid level often maintained these differences also at the tetraploid level. However, in certain populations, combining ability at the diploid and tetraploid levels is not the same. Such cases were observed when different/monogerm parental stocks were crossed with each other. Probably such differences are conditioned by the increased heterozygosity in tetraploid F_1 hybrids in comparison with the heterozygosity in F_1 diploid hybrids. The rise in heterozygosity in F_1 tetraploid hybrids is conditioned by the shift from diploid heredity to the tetraploid one (Tables 5 and 6).

Among the diploids studied, we observed 2 groups of stocks differing in combining ability. The first group was comprised of multigerm diploid populations which produced higher yield of roots in F_1 hybrids than the middle parent and the parental inbred line.

The tetraploid F_1 hybrids derived from the stocks of the same group also showed a higher yield than the middle parent or parental inbred line. However,

Table 4.--F_1 diploid hybrids between MS 91 monogerm and multigerm populations: (SLC 15 monogerm, US 35/2, US 104, and US 401).

	Tons roots			Percent sucrose		
	Diploid parents and $\frac{P_1 + P_2}{2}$ 1/	Diploid F_1	Difference	Diploid parents 1/	Diploid F_1	Difference
SLC 91 monogerm	22.08760	---		13.3750	---	
SOC 15 monogerm	a: 22.08760	24.0667	+ 1.9791	a: 13.3750	13.9833	+ 0.6083
	b: 27.5501	24.0667	- 3.4834	b: 13.3200	13.9833	+ 0.6633
	c: 24.8189	24.0667	+ 0.7522	c: 13.3475	13.9833	+ 0.6358
US 35/2	a: 22.0876	32.3001	+ 10.2125	a: 13.3750	13.4500	+ 0.0750
	b: 29.3709	32.3001	+ 2.9292	b: 13.6750	13.4500	- 0.2250
	c: 25.7293	32.3001	+ 6.5708	c: 13.5250	13.4500	- 0.0750
US 104	a: 22.0876	31.7063	+ 9.6187	a: 13.3750	12.7500	- 0.6250
	b: 29.0146	31.7063	+ 2.6917	b: 12.9200	12.7500	- 0.1700
	c: 25.5511	31.7063	+ 6.1552	c: 13.1475	12.7500	- 0.3975
US 401	a: 22.0876	29.3709	+ 7.2833	a: 13.3750	13.0600	- 0.3150
	b: 29.7272	29.3709	- 0.3563	b: 12.4500	13.0600	+ 0.6100
	c: 25.9074	29.3709	+ 3.4635	c: 12.9125	13.0600	+ 0.1475
msd at 5% point			3.4989			0.6649
lsd at 1% point			4.6078			0.8756

1/ a: P_1 = 2n SLC 91 monogerm
b: P_2 = pollinators
c: $\frac{P_1 + P_2}{2}$ (calculated mean)

Table 5.--Percent sucrose and tons of roots in tetraploid F_1 and in tetraploid parents.

	Tons roots			Percent sucrose		
	Tetraploid parents and $\frac{P_1 + P_2}{2}$ 1/	Tetraploid F_1 2/	Difference between tetraploid parents and F_1	Tetraploid parents 1/	Tetraploid F_1 2/	Difference between tetraploid parents and F_1
SLC 91 monogerm	23.0771			14.0467		
SLC 15 monogerm	a: 23.0771	30.4001	+ 7.3230	a: 14.0467	13.7000	- 0.3467
	b: 27.1146	30.4001	+ 3.2855	b: 13.7050	13.7000	- 0.0050
	c: 25.0959	30.4001	+ 5.3042	c: 13.8758	13.7000	- 0.1758
US 35/2	a: 23.0771	31.1126	+8.0355	a: 14.0467	13.5083	- 0.5384
	b: 29.5292	31.1126	+1.5834	b: 13.2167	13.5083	+0.2916
	c: 26.3032	31.1126	+4.8094	c: 13.6317	13.5083	- 0.1234
US 104	a: 23.0771	30.3209	+7.2438	a: 14.0467	12.8400	- 1.2067
	b: 33.6855	30.3209	- 3.3646	b: 12.9800	12.8400	- 0.1400
	c: 28.3813	30.3209	+1.9396	c: 13.5133	12.8400	- 0.6733
US 401	a: 23.0771	29.0938	+6.0167	a: 14.0467	13.0500	- 0.9967
	b: 35.2688	29.0938	- 6.1750	b: 13.0800	13.0500	- 0.0300
	c: 29.1729	29.0938	- 0.0791	c: 13.5633	13.0500	- 0.5133
msd at 5% point			3.4989			0.6649
lsd at 1% point			4.6078			0.8756

1/ a: ♀ SLC 91 monogerm (P_1) tetraploid

b: ♂ Pollinator (P_2) tetraploid

c: $\frac{P_1 + P_2}{2}$ (calculated mean) tetraploids

2/ Data from Table 7, page 67.
Data for parents from Table 3, page 60.

Table 6.--Percent sucrose and tons of roots in F_1 tetraploid hybrids and diploid ancestors.

	Tons roots			Percent sucrose		
	Diploid ancestors and $\frac{P_1 + P_2}{2}$ 1/	Tetraploid F_1 2/	Difference between diploid ancestors & tetraploid hybrids	Diploid ancestors 1/	Tetraploid F_1 2/	Difference between diploid ancestors & tetraploid hyb.
SLC 91	22.0876			13.3750		
SLC 15 monogerm	a: 22.0876	30.4001	+ 8.3125	a: 13.3750	13.7000	+0.3250
	b: 27.5501	30.4001	+ 2.8500	b: 13.3200	13.7000	+0.3300
	c: 24.8189	30.4001	+ 5.5812	c: 13.3475	13.7000	+0.3225
US 35/2	a: 22.0876	31.1126	+ 9.0250	a: 13.3750	13.5083	+0.1333
	b: 29.3709	31.1126	+ 1.7417	b: 13.6750	13.5083	- 0.1667
	c: 25.7293	31.1126	+ 5.3833	c: 13.5250	13.5083	- 0.0167
US 104	a: 22.0876	30.3209	+ 8.2333	a: 13.3750	12.8400	- 0.5350
	b: 29.0146	30.3209	+ 1.3063	b: 12.9200	12.8400	- 0.0800
	c: 25.5511	30.3209	+ 4.7698	c: 13.1475	12.8400	- 0.3075
US 401	a: 22.0876	29.0938	+ 7.0062	a: 13.3750	13.0500	- 0.3250
	b: 29.7272	29.0938	- 0.6334	b: 12.4500	13.0500	+0.6000
	c: 25.9074	29.0938	+ 3.1864	c: 12.9125	13.0500	+0.1375
msd at 5% point			3.4989			0.6649
lsd at 1% point			4.6078			0.8750

1/ a: SLC monogerm (diploid)

b: Pollinator (diploid)

c: $\frac{P_1 + P_2}{2}$ (calculated mean) (diploid)

2/ Data from Table 7, page 67.

Data for parents from Table 3, page 60.

in both cases F_1 hybrids (diploid and tetraploid) did not significantly exceed in yield their best yielding parent (Tables 4, 5 and 6). Generally, F_1 tetraploid hybrids between the monogerm male-sterile strain and multigerm populations yielded a little to F_1 diploid hybrids in weight of root, although this decrease could not be statistically proved. In percent sucrose, F_1 tetraploid hybrids also had no advantage in comparison with F_1 diploid hybrids (Table 3). In this way, the tetraploid multigerm varieties composing this group did not show advantages in combining ability in comparison with their diploid ancestors.

The second group of diploid stocks included monogerm strains. F_1 diploid hybrids between monogerm SLC 91 and monogerm self-sterile SLC 15 were significantly lower in yield than the monogerm self-sterile population SLC 15 itself. The same F_1 hybrid at the tetraploid level was otherwise. In spite of a certain degree of relationship between parents, the F_1 tetraploid hybrid produced a significantly higher yield than the diploid F_1 hybrid. The percent sucrose in this tetraploid F_1 hybrid was also high enough (Tables 5, 6, and 7). The monogerm F_1 tetraploid hybrid between SLC 91 and SLC 15 was very close in yield to the yield of the F_1 diploid hybrid 2n SLC 91 and different multigerm variety pollinators. It is probable that the increase of yield in the F_1 tetraploid hybrids is conditioned by the higher resistance of tetraploids to inbreeding and inbreeding depression than is peculiar to diploid sugar beets.

Combining Ability in Triploids

Ten triploid monogerm male-sterile F_1 hybrids have been studied in this experiment. Triploids were obtained by hybridization of male-sterile monogerm strains with 5 different pollinators. Each triploid combination consisted of 2 types of hybrids derived from crosses of 2n MS X 4n pollinator and of 4n MS X 2n pollinator.

Yield of Root in Triploid Hybrids

Triploids showed a different weight of root. The lowest yield was observed in triploids which carried all 3 genomes from the inbred line SLC 91 and which were derived from crosses of 2n MS SLC 91 to 4n SLC 91, or from crosses of 4n

Table 7.--F_1 diploid and tetraploid monogerm hybrids between MS SLC 91 and monogerm self-sterile SLC 15, US 35/2, US 104, and US401.

	Tons roots			Percent sucrose		
	Diploid F_1	Tetraploid F_1	Difference	Diploid F_1	Tetraploid F_1	Difference
SLC 91 monogerm						
SLC 15 monogerm	24.0667	30.4001	+6.3334	13.9833	13.7000	- 0.2833
US 35/2	32.3001	31.1126	- 1.1875	13.4500	13.5083	+0.0583
US 104	31.7063	30.3209	- 1.3854	12.7500	12.8400	+0.0900
US 401	29.3709	29.0938	- 0.2771	13.0600	13.0500	- 0.0100
msd at 5% point			3.4989			0.6649
lsd at 1% point			4.6078			0.8756

MS SLC 91 to 2n SLC 91. All other triploids obtained from the hybridization of 2n MS SLC 91 with any multigerm pollinator showed significantly higher yields than the above-mentioned triploids with 3 similar genomes (Tables 8 and 9).

Generally, all triploids were distinguished by a very high yield when compared with the yield of their diploid ancestors as well as with the yield of F_1 diploid hybrids derived from crosses of corresponding diploid parents (Tables 7, 8 and 9).

A study of F_1 diploid hybrids obtained from crosses of 2n MS SLC 91 with commercial multigerm populations showed that they exceeded in yield their higher yielding parent only a little and insignificantly. Triploids obtained from crosses of the same strains showed a higher yield. All 6 corresponding F_1 triploid hybrids exhibited a significantly higher yield than their multigerm diploid higher yielding parents.

A comparison of yield in F_1 triploid hybrids with the yield of F_1 corresponding diploid hybrids indicated that triploid hybrids are higher in yield. This was statistically proved for the following triploid hybrids (Table 9):

SLC 91 X US 104

SLC 91 X US 401

SLC 91 X monogerm self-sterile SLC 15.

The last triploid obtained from hybridization of 2 monogerm parents is especially interesting. Both triploid hybrids derived from crosses of monogerm strains showed a higher yield than their diploid monogerm self-sterile parent SLC 15. This difference is significant (Table 9).

It was difficult to expect heterosis in F_1 diploid hybrids MS SLC 91 X SLC 15, because of the relationship of parental strains, but at the triploid level the yield of the same hybrid was highly increased. In the case given, the triploid hybrids exceeded the yield of the hybrid combination which was not productive at the diploid level.

The tendency of triploid F_1 hybrids to increase yield in crosses between related strains was manifested also in triploid hybrids within an inbred line (2n MS SLC 91 X 4n SLC 91 and 4n MS SLC 91 (Tables 8 and 9).

Table 8.--Monogerm triploid MS hybrids and diploid ancestors.

	Tons roots			Percent sucrose		
	Diploid pollinator	Triploid F_1 1/	Difference	Diploid population	Triploid F_1 1/	Difference
SLC 91 monogerm	22.0876	a: 27.3521 b: 27.7480	5.2645 5.6604	13.3750	a: 13.8333 b: 13.7833	+0.4583 +0.4083
SLC 15 monogerm	27.5501	a: 31.6667 b: 34.3188	4.1166 6.7687	13.3200	a: 13.6800 c: 13.4925	+0.3600 +0.1725
US 35/2	29.3709	a: 35.1105 b: 34.2001	5.7396 4.8292	13.6750	a: 13.7583 c: 13.7500	+0.0833 +0.0750
US 104	29.0146	a: 37.6042 c: 37.8417	8.5896 8.8271	12.9200	a: 13.4500 b: 13.5100	+0.5300 +0.5900
US 401	29.7272	a: 35.8229 b: 37.1293	6.0957 7.4021	12.4500	a: 13.5000 c: 13.6000	+1.0500 +1.1500
msd at 5% point			3.4989			0.6649
lsd at 1% point			4.6078			0.8756

1/ a: ♀ monogerm diploid MS SLC 91 X tetraploid pollinator

b: ♂ monogerm tetraploid MS SLC 91 X diploid pollinator

Table 9.--Monogerm triploid and diploid MS hybrids.

	Tons roots			Percent sucrose		
	Diploid F_1	Triploid F_1	Difference	Diploid F_1	Triploid F_1	Difference
SLC 91 monogerm	22.0876[1]	27.3521	5.2645	13.3750[1]	13.8333	+0.4583
		27.7480	5.6604		13.7833	+0.4083
SLC 15 monogerm	24.0667	31.6667	7.6000	13.9833	13.6800	- 0.3033
		34.3188	10.2521		13.4925	- 0.4908
US 35/2	32.3001	35.1105	2.8104	13.4500	13.7583	+0.3083
		34.2001	1.9000		13.7500	+0.3000
US 104	31.7063	37.6042	5.8979	12.7500	13.4500	+0.7000
		37.8417	6.1354		13.5100	+0.7600
US 401	29.3709	35.8229	6.4520	13.0600	13.5000	+0.4400
		37.1293	7.7584		13.6000	+0.5400
msd at 5% point			3.4989			0.6649
lsd at 1% point			4.6078			0.8756

[1]Tonnage and sucrose in SLC 91 monogerm inbred

Triploid hybrids obtained in this way were lower in yield than any other triploids tested in this experiment. However, in spite of this, higher vigor and yield in these triploids within a line, in comparison with their diploid parents, was statistically proved.

<u>Percent Sucrose in Triploid Hybrids</u>

In the F_1 diploid hybrids tested the percent sucrose showed a tendency to increase when compared with diploid pollinators mainly in those cases when diploid F_1 hybrids did not show a noticeable increase in yield in comparison with the diploid pollinators (Table 4).

Such an increase in percent sucrose in F_1 diploid hybrids by 0.6% was observed in the F_1 hybrid SLC 91 X monogerm self-sterile SLC 15 and in the F_1 hybrids SLC 91 X US 401. In both cases the yield of the F_1 hybrid did not exceed the yield of the diploid pollinator.

Generally, triploid hybrids appeared to be higher in sucrose than the diploid F_1 hybrids (Table 9).

All triploid hybrids obtained from hybridization of SLC 91 with multigerm populations (US 401, US 104, US 35/2) showed higher sucrose than the diploid F_1 hybrids of corresponding parents. However, a significant excess of sucrose was observed only in a triploid hybrid with US 104.

The percent sucrose in triploid hybrids also appeared to be higher than percent sucrose in their diploid pollinators. But here also this excess was significant in one case only--a case in which both triploid hybrids with US 401 percent sucrose was much higher than in their multigerm pollinator.

In this way, several high-yielding triploids showed the tendency to maintain higher percent sucrose than the percent sucrose in diploid F_1 hybrids or in corresponding diploid pollinators.

Conclusion

1. Changes of percent sucrose and weight of root in tetraploid populations or in inbred lines caused by doubling of chromosomes are not identical in different sugar beet strains.

2. Combining ability in sugar beets appeared to be different at diploid, triploid and tetraploid levels.

3. Combining ability in diploids. When the diploid male-sterile equivalent of inbred line 91 was crossed to different diploid populations (US 104, US 401, US 35/2, monogerm self-sterile SLC 15) the yield of F_1 diploid hybrids was higher than the yield of the inbred parent and also higher than that of the middle parent. Diploid F_1 hybrids also exceeded a little in yield the higher yielding multigerm parent, but this excess was not significant.

When related monogerm strains were crossed, the F_1 diploid hybrid was even lower in yield than the higher yielding monogerm parent, but the percent sucrose in this hybrid was higher than in the higher sucrose parent.

4. Combining ability in tetraploids. Hybridization of nonrelated tetraploids did not exhibit better combining ability than hybridization of diploids. When related tetraploid strains were intercrossed, the combining ability was better than in corresponding diploid strains.

5. Combining ability in triploids. Triploid hybrids showed, in comparison with the diploid and tetraploid hybrids, the best combining ability. F_1 triploid hybrids exceeded significantly in yield the higher yielding parent. It was observed in several cases that triploid F_1 hybrids showed a significantly higher yield than the corresponding diploid F_1 hybrids.

6. Better combining ability of triploids in comparison with F_1 diploid hybrids was observed also in crosses of comparatively related strains. The monogerm triploid hybrids obtained in this way may represent a special interest for breeding of monogerm varieties.

PRODUCTION OF POLYPLOID STRAINS

By Helen Savitsky

(a) In 1959, tetraploid plants were selected in the C_0 generation and intercrossed within the strain of the following strains:

No. 537 leaf-spot-resistant monogerm self-fertile inbred line

No. 127 monogerm self-fertile inbred line, high in sugar (Z type)

No. 171 monogerm self-fertile high-yielding inbred line (E type)

No. 509 F_1 hybrid CT9 X CT5

No. 821 Mendelian male-sterile

No. 588 cytoplasmic male-sterile monogerm line (plasm from curly-top-resistant X 610)

No. 168 cytoplasmic male-sterile monogerm line (plasm from Klein Z X 91)

No. 573 self-sterile monogerm population high in curly-top resistance

Janasz No. 3 self-sterile multigerm population, high in sugar

Seed was harvested separately from each plant and planted in cylinders, and 100-120 young C_1 plants were obtained from each strain. They were kept in a coldframe for thermal induction. During the winter of 1959-60 the chromosome number was determined in 1,020 plants. The nigrosine leaf-smear method was used for chromosome determination. Pure tetraploid plants were selected in each strain, and groups of tetraploid plants were composed of every strain (70-80 plants in a group). These groups were propagated in isolations by V. F. Savitsky. In this way C_2 tetraploid seed was obtained for each of the above-mentioned strains.

(b) Four new tetraploid strains were in production in 1960. These strains were as follows:

1. SLC 23, a highly leaf-spot-resistant monogerm inbred line.
2. No. 20, a self-sterile monogerm population derived from backcrosses of No. 101 to Klein E (Einbeck).
3. Nematode-resistant line developed by Charles Price
4. A nematode-resistant line developed by the American Crystal Sugar Company

Seedlings of these lines were treated by colchicine in the fall of 1959. Seedlings affected with colchicine were selected and kept in a coldframe during the winter for thermal induction. In the spring they were transplanted into the field. At flowering time tetraploid C_0 plants were selected after examination for size of pollen grains. 705 plants were examined for size of pollen grains. Selected tetraploid plants were bagged and intercrossed within the strain. C_1 seed was harvested separately from every plant.

A METHOD OF PRODUCTION OF TETRAPLOID SUGAR BEETS BY SEED TREATMENT

By Helen Savitsky

Results first obtained from colchicine treatment of sugar beet seedlings and seed in 1952 indicated that treated seedlings produced about 10-12% tetraploids, whereas from treatment of seed the percent of tetraploids rose to about 40. Although only a few seeds were used for the experiment at that time, this indication led to further examination of the effectiveness of seed treatment in sugar beets.

An experiment was started in 1958 and continued for three years. The purpose of this experiment was to work out a highly effective method of colchicine treatment which would produce tetraploids with a minimum of work and expense. The results are presented in this brief report.

Materials and Methods

Three kinds of seed were exposed to treatment: "germinated seed," "swollen seed," and "dry seed."

1. "Germinated seed" included three groups differing in length of root tips. Before germination the seed was washed in running water for three hours and then put on wet blotting paper to germinate in cuvettes, the lids of which were also covered with wet blotting paper on the inside. Cuvettes were kept at 25°C. Germinating seed was distributed into three groups. Group A contained seed just starting to germinate, with little white root tips just showing from the seed. Group B consisted of seed with length of root tips not exceeding 0.5 cm. In group C the length of root tips varied from 0.5 to 1.0 cm. Seed of all three groups was exposed to a treatment of the following colchicine concentrations: 0.1, 0.2, 0.3, 0.4, 0.5, and 0.8 percent. (In the tables, symbol A-1 indicates that seed of group A was treated by the 0.1 concentration; B-2 indicates that seed of the group was treated by the 0.2 concentration, etc.) Treatment lasted 6 hours. Longer treatment was not used to avoid mortality of seedlings which are very sensitive to the poisoning effect of colchicine at that stage of germination. For the same reason longer treatment has no practical importance.

"Germinated seed" of the following strains was treated:

(a) From 2 self-sterile populations: Janasz No.3 multigerm and No. 573 monogerm derived from backcrosses of No. 101 mm to curly-top-resistant varieties.

(b) From 4 monogerm self-fertile inbred lines: No. 171, No. 127, No. 200, and No. 537.

The experiment was conducted in 2 replications.

2. "Swollen seed" was prepared as follows: Seed was washed for 3 hours in running water, then put on the wet blotting paper in cuvettes similar to those used for germinated seed and kept at 25° C. for 36-40 hours -- until the time single seed started to show the little white root tips. During this time the seed became swollen but had not started to germinate. This swollen seed was exposed to treatment by the same colchicine concentrations as germinated seed, but for 6 and 16 hours. Swollen seed exposed to such treatment must not have wet surfaces. If too wet, the swollen seed was scattered on a towel on a table for 1-2 hours to dry.

3. "Dry seed" was exposed to treatment by the same colchicine concentrations, without any preparation, for 6 and 16 hours.

Material used for treatment of both swollen and dry seed was self-sterile monogerm population No. 20 derived from backcrosses of No. 101 mm to Klein E (Einbeck) and self-sterile monogerm population US 75 derived from backcrosses of No. 101 mm to variety US 75.

Experiments with swollen and dry seed were conducted in 3 replications with an equal number of seed treated and planted in each replication. Swollen seed was marked D, dry seed was marked E, and standard (untreated seed), F. All treatments were conducted in August and September.

In all experiments, seed was put in little beakers and covered by a colchicine solution of a certain concentration. During treatment, a temperature of 27° C. was maintained. After treatment, seed was quickly rinsed twice in water and planted in flats or beds of soil in the greenhouse.

After germination seedlings were classified as affected or unaffected. All unaffected seedlings with thin hypocotyls, normal leaves, and rapid growth were pulled out. Affected seedlings showed differing grades of thickened hypocotyls, and thickened, dissected, and lobed first leaves. They were short and grew slowly. Heavier colchicine concentrations showed a stronger effect: Hypocotyls were too swollen and short and the leaves too lobed and dissected. A certain percent of such seedlings did not survive.

Affected seedlings were kept in the flats until they became big enough to be transplanted (about one month). They were transplanted into thin cylinders and after rooting they were transferred to coldframes for further growth and thermal induction during the winter.

In the spring seedlings were transplanted to the field where they developed seedstalks and flowered. During the flowering period the size of pollen grains was examined on each plant.

Only plants having flowers in the main inflorescence with anthers on which big, diploid pollen grains were found exclusively were classified as tetraploids. It is obvious that in the C_0 generation no plant is a really pure tetraploid. They all carried mixed diploid and tetraploid tissues (chimeras), but many plants derived from affected seedlings developed the main inflorescence, having diploid gametes exclusively or almost exclusively. If even an insignificant number of haploid gametes appeared in them, which were not noticed upon examination, these plants were successfully used as tetraploids for production of the next tetraploid generation. Sometimes on such tetraploid plants lower branches developing on the lower part of the seedstalk were diploids; therefore, lower branches were never used for seed production without special examination for the size of pollen grains. Only tetraploid plants were used for seed production. All diploids as well as all chimeras (which carried in some flowers diploid and in others haploid pollen grains) were sorted out. The tetraploid plants were covered with pollinating paper bags and intercrossed within a strain by exchanging bags about 2 weeks later.

Seed was harvested from each plant separately and planted in the fall in small pots or cylinders in the greenhouse. To maintain the same or nearly the same genetical composition of a population (even of an inbred line which was turned into a tetraploid),seed from not less than 60 or 70 tetraploid C_o plants was planted. The aim was to have only 100-120 plants for each strain; therefore, only 2 or 4 seeds from each tetraploid C_o plant were planted. Young plants (120 for the strain) thus obtained were kept in cold frames in winter and examined during the winter for chromosome number by using nigrosine leaf smears. Pure tetraploid plants were selected from 100-120 plants examined. A group consisting of 70-80 tetraploid plants was transplanted to an isolation in the spring for seed production under open-pollination. Different strains were propagated in different isolations. When an inbred line was propagated, some branches on the plants were bagged for selfing, while others produced seed under open-pollination.

Seed set was always abundant in self-sterile strains. Fresh tetraploid inbreds differed in their ability for propagation.

A total of 15,502 seeds was treated in this experiment and 1,338 plants were examined for size of pollen grains.

Experimental Results

Seed germination. The percentage of seedlings coming up after treatment of germinated seed of self-sterile populations, varieties Janasz and No. 573 mm, equalled only 20.60 (Table 1). (From 3,936 seeds only 811 seedlings came up.) In the treated inbred lines seed germination was generally higher. 6,526 seeds of 4 inbreds produced 2,775 seedlings; i.e., the germination equalled 42.52% (Table 2). In all these strains, in self-sterile as well as in self-fertile, seed germination was highly reduced by the method of treatment used.

An especially big reduction in seed germination was observed in group C for strains with a low percent or low rate of seed germination. Colchicine concentration 0.8 caused high mortality (5% or 7% of germination in self-sterile strains).

Table 1.--Effect of colchicine treatment in germinated seed of two self-sterile populations in percent

	Seed germination	Seedlings affected and surviving	4n plants obtained
A-1	35.00	40.00	16.67
A-2	27.08	38.46	53.85
A-3	34.80	21.13	38.46
A-4	49.38	45.57	40.00
A-5	26.89	32.03	57.78
A-8	7.39	33.33	0
Total	28.85	34.66	44.54
B-1	27.45	61.90	57.70
B-2	19.16	26.83	50.00
B-3	23.77	22.41	66.67
B-4	27.78	44.61	39.13
B-5	18.58	21.43	33.33
B-8	8.95	17.65	0
Total	21.05	34.34	48.68
C-1	64.06	66.67	78.57
C-2	10.84	27.78	100.00
C-3	14.53	44.00	60.00
C-4	1.12	40.74	66.67
C-5	5.71	37.50	66.67
C-8	5.77	33.33	0
Total	9.96	42.86	68.18
Grand total	20.60	35.76	50.21

Table 2.--Effect of colchicine treatment in germinated seed of four self-fertile inbred lines in percent.

	Seed germination	Seedlings affected and surviving	4n plants obtained
A-1	55.37	39.55	38.46
A-2	46.59	34.48	41.67
A-3	52.92	14.46	64.71
A-4	44.09	13.77	47.06
A-5	42.53	18.34	72.31
A-8	41.56	0	0
Total	45.62	19.71	56.17
B-1	51.76	59.85	61.54
B-2	32.63	24.73	53.33
B-3	43.09	14.50	65.38
B-4	32.54	12.14	80.00
B-5	39.84	13.37	76.47
B-8	23.56	1.89	0
Total	36.99	21.30	65.00
C-1	69.92	33.94	61.54
C-2	60.00	16.07	76.47
C-3	53.39	19.46	73.33
C-4	34.68	8.74	60.00
C-5	27.78	25.00	80.00
C-8	33.01	8.91	0
Total	44.97	19.72	68.92
Grand total	42.52	20.18	61.80

For inbreds showing better seed germination in this experiment, higher concentrations of colchicine were not so harmful, although in the groups A and B the concentration of 0.8 reduced the percent of germination, and in group C the percent of germination fell down at concentrations of 0.5 and 0.8. Longer root tips were also more sensitive in these lines.

Germination of treated swollen and dry seed (Tables 3 and 4) was almost normal and approached closely the percent of germination of untreated seed (F) of the same sample. For the 16-hour treatment, the percent of germination of swollen seed was a little lower, but still very high. Germination of dry seed was not affected by the duration of treatment. None of the colchicine concentrations was harmful for the germination of swollen or dry seed.

Seedlings affected. In self-sterile populations 35.76% of the seedlings were affected by colchicine (290 seedlings from 811) (Table 1). In groups A and B the effect of colchicine treatment was the same (34%) and a little higher in the group C (42.86%). The effect of different concentrations within the groups varied indicating no regularity. It was noticed also that the low concentrations (0.1 and 0.2) were as effective in their affect on the seedlings, or even more effective than the heavier ones (0.4 or 0.5). The concentration 0.8 was no more effective in the production of affected seedlings than the lower concentrations. The affect produced by this concentration was too strong. Many affected seedlings developed very thick and short hypocotyls; their first leaves were too short and thick. Such seedlings grew very slowly and the majority of them died within 2 or 3 weeks after germination.

In self-fertile strains fewer seedlings were affected than in self-sterile ones. From 2,775 seedlings 560, or 20.18%, were affected (Table 2).

The effectiveness of treatment was approximately the same in all 3 groups (A, B, and C), varying from 19.71% to 21.30%. The longer root tips did not show a positive effect in this material, which can be explained by the slow rate of growth and the decrease of colchicine concentration in the root tips before the point of growth started to develop.

Table 3.--Effect of colchicine treatment of swollen seed in percent in strain No. 20 mm.

	Seed germinated	Seedlings affected and surviving	4n plants obtained		Seed germinated	Seedlings affected and surviving	4n plants obtained
		At 6 hours				At 16 hours	
D-1	100.00	0	0	D-1	97.14	0	0
D-2	98.10	27.18	21.43	D-2	100.00	45.71	43.48
D-3	97.14	33.33	40.00	D-3	80.95	52.94	35.19
D-4	94.29	41.41	37.50	D-4	92.38	61.86	66.67
D-5	85.71	48.89	27.78	D-5	88.57	72.04	48.89
D-8	91.43	44.79	41.18	D-8	44.76	63.83	55.00
Total F	94.44 99.05	31.93	34.69		83.97	47.26	46.99

Effect of colchicine treatment of dry seed in percent in the strain No. 20 mm.

	Seed germinated	Seedlings affected and surviving	4n plants obtained		Seed germinated	Seedlings affected and surviving	4n plants obtained
		At 6 hours				At 16 hours	
E-1	97.14	0	0	E-1	98.06	0	0
E-2	80.00	7.14	50.00	E-2	99.04	14.42	57.14
E-3	80.00	8.33	80.00	E-3	97.14	26.47	53.33
E-4	72.38	28.95	66.67	E-4	95.24	40.00	54.55
E-5	81.90	31.40	62.96	E-5	98.10	41.75	59.09
E-8	81.90	27.47	72.73	E-8	96.19	34.65	50.00
Total	83.02	16.63	64.29		97.30	26.00	54.92

Table 4.--Effect of colchicine treatment of swollen seed in percent in the strain US 75 mm.

	Seed germinated	Seedlings affected and surviving	4n plants obtained		Seed germinated	Seedlings affected and surviving	4n plants obtained
		At 6 hours				At 16 hours	
D-1	67.62	0	0	D-1	78.10	0	0
D-2	66.67	0	0	D-2	75.24	40.51	83.33
D-3	72.38	28.95	8.33	D-3	66.67	52.86	28.57
D-4	65.71	28.99	50.00	D-4	47.62	32.00	75.00
D-5	70.48	39.19	70.00	D-5	52.38	43.64	58.33
D-8	68.57	36.11	33.33	D-8	60.00	38.10	40.00
Total	68.57	22.45	43.33		63.33	33.33	57.14
F	68.57						

Effect of colchicine treatment of dry seed in percent in the strain US 75 mm.

	Seed germinated	Seedlings affected and surviving	4n plants obtained		Seed germinated	Seedlings affected and surviving	4n plants obtained
		At 6 hours				At 16 hours	
E-1	80.95	0	0	E-1	82.86	0	0
E-2	66.67	0	0	E-2	85.71	3.33	0
E-3	74.29	1.28	0	E-3	74.29	10.26	33.33
E-4	73.33	5.19	0	E-4	59.05	25.81	66.67
E-5	78.10	9.76	42.86	E-5	60.95	20.31	75.00
E-8	62.86	15.15	66.67	E-8	74.29	33.33	60.00
Total	72.70	5.02	30.43		72.86	14.38	62.00

Low colchicine concentrations (0.1 and 0.2) were the most effective for this material in every group. Concentration 0.8 was too strong and even more injurious for inbred lines studied than for the above-mentioned self-sterile strains. None or almost no affected seedlings survived in the different groups after treatment by the 0.8 concentration.

Swollen seed after 6 hours of treatment produced 31.93% affected seedlings in strain No. 20 and 22.45% in strain US 75 (Tables 3 and 4). After 16 hours of treatment the percent of affected seedlings was much higher. It equalled 47.26 in strain No. 20 and 33.33 in US 75. Swollen seed of No. 20 after 16 hours of treatment produced the highest number of affected seedlings in the experiment, much higher than was obtained by the treatment of germinated seed. In strain US 75 the number of affected seedlings obtained after the same treatment was also high and approached the highest number of affected seedlings in germinated seed observed in self-sterile populations (35.76%). This indicated the high effectiveness of the treatment of swollen seed for 16 hours.

When dry seed was treated for 6 hours it produced 16.63% affected seedlings in strain No. 20 and only 5.02% in strain US 75. After 16 hours of treatment the percent of affected seedlings increased to 26.10 in strain No. 20 and to 14.38 in US 75. Treatment for 16 hours always produced a higher percent of affected seedlings than the 6-hour treatment in both strains.

Treatment of dry seed was inferior to treatment of swollen seed of the same strain. For practical purposes not only the percent, but also the number of affected seedlings, is highly important. A comparison of the number of affected seedlings obtained after treatment of swollen and of dry seed, where the same quantity of seed was treated in every part of the experiment, shows that the highest number of seedlings was affected by the treatment of swollen seed for 16 hours. Dry seed produced in all cases, at 6 and 16 hours of treatment, a much lower quantity of affected seedlings than the treated swollen seed.

Percent of Tetraploid Plants Obtained. Not all affected seedlings reached the flowering stage. Some of them died before being transplanted in the field in the spring; others did not bolt or were lost because of breakage, etc. Therefore, the percent of tetraploid plants obtained was calculated from the number of plants checked in the field for size of pollen grains.

In the self-sterile populations Janasz and No. 573, 50.21% of the plants checked were tetraploids (120 of 239) (Table 1). The percent of tetraploid plants increased from group A to group C (44.54%, 48.68%, 68.18%). Different colchicine concentrations within the groups produced a modifying number of tetraploid plants, but they all were close in their effectiveness. The concentration of 0.1 in group A was less effective than all others. From the concentration of 0.8 no tetraploid plants were obtained, because only 3 affected seedlings after treatment with the 0.8 concentration reached the flowering stage, and all were diploids.

Self-fertile inbred lines produced a higher percent of tetraploid plants (61.80%, 220 tetraploid plants from 356 plants checked) (Table 2). Although the number of seedlings affected was lower in this material, the percent of tetraploid plants obtained was a little higher. Probably the seedlings were more affected than in the self-sterile strains. As in self-sterile populations, the percent of tetraploid plants increased from group A to group C (56.17%, 65.00%, 68.92%). No regular differences were observed in the effectiveness of different concentrations from 0.2 to 0.5 in the production of tetraploids within the groups. The concentration of 0.1 in group A was also less effective. In spite of the production of a higher percent of affected seedlings in self-steriles as well as in self-fertile strains, the concentration of 0.1 was less effective in the production of tetraploid plants in both kinds of materials, and the concentration of 0.2 did not differ in effectiveness from the other concentrations. This discrepancy in the action of low colchicine concentrations on the production of affected seedlings and tetraploid plants was due to the fact that by treatment with the 0.1 and 0.2 concentrations the mortality of affected seedlings was not as high as after treatment by heavier dosages of colchicine,

and therefore the number of affected seedlings was increased. At the same time, the effect of treatment of the 0.1 concentration was not as strong as the effect of other concentrations and produced less tetraploid plants. Treatment with the 0.2 concentration did not differ from other concentrations in the intensiveness of the production of tetraploid plants. From the concentration 0.8 no tetraploid plants were obtained, because only 1 plant reached flowering stage after such treatment.

Swollen seed treated for 6 hours produced in strain No. 20, 34.69% tetraploids; in strain US 75, 43.33% (Tables 3 and 4). After 16 hours of treatment the percent of tetraploid plants increased in strain No. 20 to 46.99 and in strain US 75 to 57.14.

In strain No. 20, 6 hours of treatment with a colchicine concentration of 0.1 did not affect the seedlings; therefore, plants could be checked for pollen grain size starting from the 0.3 concentration. Concentration 0.3 produced the lowest percent of tetraploid plants (21.43). In strain US 75, concentration 0.3 was the lowest affecting the seedlings. This concentration also produced the lowest percent of tetraploids (8.33). All other concentrations produced in both strains a varying and comparatively close percent of tetraploids (27.78% to 41.18% in strain No. 20 and 33.33% to 50.00% in US 75).

All colchicine concentrations, starting from 0.3 and after 16 hours of treatment of swollen seed, produced in both strains a higher percent of tetraploid plants which varied without regularity.

Treatment of dry seed for 6 hours showed in strain No. 20 a higher percent of tetraploids produced (64.29) than in swollen seed after 6 hours of treatment, and in strain US 75 a much lower percent of tetraploids was produced (30.43) in comparison with swollen seed. The big variation in the number of seedlings affected and in the percent of tetraploids produced are typical of the treatment of dry seed, especially if the treatment was given only 6 hours. Therefore, in all experiments swollen seed produced more affected seedlings than dry seed.

From the 6-hour treatment of dry seed, plants could be examined for size of pollen grains, starting from the concentration 0.2 in No. 20 and from 0.3 in US 75 (lower concentrations did not affect seedlings). In strain No. 20, all colchicine concentrations were highly effective; in the strain US 75, concentrations 0.5 and 0.8 only were effective.

The 16-hour treatment of dry seed produced 54.92% tetraploids in strain No. 20 and 62.00% in US 75. All concentrations from 0.2 in strain No. 20 and from 0.3 in US 75 were very effective and produced a high percent of tetraploid plants (usually over 50 percent).

Contrasted to germinated seed, concentration 0.8 could be used for treatment of swollen seed and dry seed at 6 and 16 hours of treatment, because the viability of seedlings was sufficient at this concentration and the percent of tetraploids produced was high.

A comparison of results obtained after treatment of dry seed and swollen seed indicates that dry seed produced a very high percentage of tetraploid plants for 16 hours of treatment. The percent of tetraploids obtained was even a little higher from the treatment of dry seed than by treatment of swollen seed for the same length of time.

The number of affected seedlings produced by treatment is very important. At a certain high level of effectiveness of treatment in the production of tetraploids, the number of seedlings affected determines the quantity of tetraploid plants obtained. In all experiments more tetraploid plants were obtained from treatment of swollen seed than from treatment of dry seed.

The highest number of tetraploid plants within the strain was obtained in the experiment after treatment of swollen seed for 16 hours.

Treatment of germinated seed produced also a high number of tetraploids. The quantity of germinated seed used for treatment was much higher (3,936 seeds for self-sterile strains Janasz and No. 573 and 6,526 seeds for 4 inbred lines against 630 seeds for swollen seed or dry seed). The percent of tetraploids obtained from the

number of treated seeds equalled 3.05 for germinated seed of the varieties Janasz and No. 573, and 3.33 for germinated seed of 4 inbred lines. The percent of tetraploid plants obtained from swollen seed of No. 20 treated for 16 hours equalled 12.38 and from swollen seed of US 75 treated for 16 hours, 9.52. Therefore, treatment of swollen seed for 16 hours appeared to be the most effective method.

Conclusions

Treatment of all kinds of seed--germinated, swollen, or dry seed--is much more effective than treatment of seedlings. The total percent of tetraploid plants obtained from all strains in this experiment equalled 52.69. Treatment of swollen seed for 16 hours appeared to be the most effective method because of the high effectiveness of the colchicine treatment and the production of a high percent of tetraploids and also because of the production of a high number of affected seedlings.

Thus, an effective and fast method for the production of tetraploids was developed, making it possible to obtain pure tetraploid strains in only 2 years.

INTERSPECIFIC HYBRIDIZATION

By Helen Savitsky

(a) In 1960, sixty first-backcross hybrid plants were grown. These hybrids were derived from backcrosses of F_1 tetraploid hybrids (4n sugar beets X 4n B. patellaris) and F_1 triploid hybrids (4n sugar beets X B. procumbens and B. webbiana) to sugar beets.

First-backcross hybrids could be distinguished by many characters. Some of them were very vigorous and resembled sugar beets; others, also resembling sugar beets, developed normally and carried some characters of the wild beet: red stripes on seedstalks and petioles, red spots on the leaves; some developed fleshy roots; others grew as wild species without forming fleshy roots. Two-thirds of them were annual and flowered the first year, about one-third did not develop seedstalks. From the plants which flowered, 3 were male-sterile. Hybrids differed also in the degree of seed setting. On some plants seed setting was abundant; others showed different grades of sterility and a few were almost sterile. There is no doubt that the first-backcross hybrids carried some chromosomes of wild beets, or probably crossover chromosomes also with genes from the species of the section Patellares.

Seed obtained was harvested from each plant separately and the hybrids themselves reserved for examination for nematode resistance.

(b) F_1 hybrid plants obtained in 1958 and 1959 were pollinated by pollen of sugar beets. As in 1959, triploid and tetraploid hybrids were semi-fertile; diploid hybrids remained sterile.

Seed from triploid and tetraploid hybrids was harvested and reserved for examination of nematode resistance in the first-backcross generation in 1961.

(c) New viable triploid hybrids have been obtained which carry 2 genomes (18 chromosomes) of B. patellaris and 1 genome (9 chromosomes) of B. vulgaris (sugar beets). Heretofore, only viable triploid hybrids with 2 genomes of B. vulgaris and 1 genome of B. procumbens were produced. The new F_1 triploid hybrids

(*B. vulgaris* X *B. patellaris*) were all annual and started to flower at the end of the season. In appearance they resembled very much triploid hybrids previously obtained which carried 18 *B. vulgaris* chromosomes and 9 *B. procumbens* chromosomes, but their branches were thinner and their leaves smaller, approaching more the wild-beet type.

Some of these new triploid hybrids died at different stages, but 50 vigorous plants are growing and are reserved for seed production in 1961.

PART V

BREEDING FOR NEMATODE RESISTANCE

and

SCREENING TESTS IN FIELD AND GREENHOUSE

Foundation Project 13

Charles Price

and

Cooperators in Nematology Investigations

PROGRESS REPORT TO THE BEET SUGAR DEVELOPMENT FOUNDATION ON BREEDING FOR NEMATODE RESISTANCE, THE HOST PARASITE RELATIONSHIP OF SUGAR BEET NEMATODE AND VARIOUS CROPS, AND CHEMICAL CONTROL OF THE NEMATODE.

(Foundation Project 13)

by Charles Price

Screening tests of new material and material from the second cycle of breeding for resistance to Heterodera schachtii were continued at Salinas, California, in 1960. Screening tests are facilitated by the use of special technique developed at Salinas and used in the greenhouse for the past several years in an effort to develop varieties resistant to the sugar beet nematode. This method of screening involves the use of soil collected from fields following a crop of sugar beets which has suffered severe damage from sugar beet nematode attack. Frequently, in addition to large numbers of nematode cysts, the soil also contains fungi causing damping-off of the seedlings and subsequent root rot. The numbers of cysts in the soil used in greenhouse tests are determined by weighing a definite amount of soil and counting the numbers of newly formed cysts by means of a microscope. A soil with approximately 200 cysts per 100 grams of soil is considered satisfactory for use in the screening tests.

In the breeding program at Salinas, thousands of sugar beets are examined for presence of nematodes on the roots. The plants are grown in a special soil mix very light in texture and to this soil is added a definite amount of the nematode infested soil. The plants are grown in greenhouse flats for a period of approximately eight weeks before they are examined for the presence of sugar beet nematodes.

If the plants examined show promise they are planted individually in aluminum cylinders in heavily infested soil and examined after approximately eight weeks. Selections for resistance have been made on the basis of absence of nematodes on the roots, seedling vigor, ability to produce a good stand under conditions of heavy exposure to nematodes, wilting resistance, and yield of roots.

The best plants are selected and subjected to an additional infestation in larger containers. The final selections are grown to seed for further evaluation and test, and for later crossing of promising lines.

Selections from a commercial field of sugar beets near Salinas, California, in 1959 were made on the basis of high vigor, relatively free from root rot evidence, and for other favorable characters. The portion of the field in which selections were made was very heavily infested with sugar beet nematode. The stand was greatly reduced and most of the remaining beets were badly stunted. There were, however, a few scattered beets which had made a good growth despite the heavy nematode population. Eighty beets were selected from the 40-acre field, removed, washed, packed, and stored in the cold room in which the temperature is maintained at 42° F. After 100 days in the coldroom, the beets were potted in 12" pots and placed in the greenhouse in which supplementary lights were installed for use at night. The almost continuous lights speeded the growth of the beets so that seed production was earlier than it would have been without the lights. A satisfactory seed set was secured on 68 (Fig.1) selected beets. These 68 beets were allowed to intercross, and the seed from each individual beet was harvested and tested in the greenhouse for resistance to nematodes. After the seed was harvested, the

Figure 1. Field selected sugar beets for nematode resistance were brought to seed after thermal induction. After seed harvest the plants were induced to bolt a second time.

Figure 2. Clones from nematode resistant beets grafted to healthy beets. The two graft unions are on either side of the healthy root.

beets were left in the greenhouse and another seed set was produced from the same beets. (Figure 1).

It is extremely difficult, however, to propagate field-grown mother beets in California because they are subjected to a number of diseases such as virus yellows, moasic, and curly top. Nematode attack togeter with other diseases so weaken the beets that after seed is produced they normally die. If after extensive testing for nematode resistance an individual beet shows promise, it is important to go back to the clone for further hybridization work. To insure this a grafting technique (Figure 2) was used and clones from some superior beets were grafted to healthy beets. These methods make it possible to use the same parent plant in hybridization with other material which has shown promise of nematode resistance. In testing the seed from each individual plant, it was observed that there was a difference among them in number of nematodes adhering to the roots and also in the vigor of seedlings. The selections from these individual beets are being tested further because the number of seedlings surviving the rigorous tests are very few. The commercial variety from which these selections were made is apparently very susceptible to combination of nematode and root rot attack.

In the breeding program, attempts are being made to combine resistance in various selected lines and to incorporate in sugar beets the high degree of resistance found in some of the wild species of beet. The material which is available for use in the breeding program includes commercial varieties, promising monogerm lines, material from irradiated seed, and crosses of sugar beet with _Beta maritima_, _B. procumbens_, and _B. webbiana_.

Testing Breeding Material. A field on the Station grounds has been selected in which an effort is made to obtain a uniform infestation with nematodes in selected areas. This field is used for testing the effects of heavy infestation of nematodes on sugar beets and for testing effects of nematodes on nematode-resistant breeding material. Tests are also being conducted at Salinas in 3-gallon crocks placed in the open field. One series of crocks contains soil with a high population of sugar beet nematodes, whereas the other series contain soil free of nematodes. Sugar beets selected for nematode resistance are planted in series of ten crocks each in the nematode-infested and nematode-free soils and comparisons in yields are made between the selections grown in the two environments. Nematode-resistant material developed at Salinas, California, is also tested in a field heavily infested with sugar beet nematode. Prior to 1960 field tests were made at Salt Lake City, Utah, in cooperation with Dr. F. V. Owen and C. H. Smith of Sugar Beet Investigations and Ed Jorgensen, Nematode Investigations. In 1960 there were no field tests at Salt Lake City, Utah, with nematode material developed at Salinas, California. We hope, however, to continue the cooperative testing of nematode-resistant material in the Logan, Utah, area in 1961.

Results. In crock tests at Salinas, California (Table 1) the selections for nematode resistance yielded 20 to 49 percent more than the moderately resistant US 41 used as check. In a field test also at Salinas (Table 2) 90 percent of the selections for nematode resistance yielded more than US 41, and thirty selections or approximately 21 percent yielded at least 50 percent better than US 41.

Work on sugar beet nematodes is being done by both the Nematology and Sugar Beet Investigations of the U.S.D.A. Studies include basic

Table 1. CROCK TEST IN WHICH NEMATODE-RESISTANT LINES WERE COMPARED WITH US 41 CHECK IN NEMATODE INFESTED AND NEMATODE FREE SOILS.

Selection	Acre yield beets tons Uninfested Tons	 Infested Tons	Increase over US 41 Tons	 Percent
834	16.58	16.76	5.52	149.1
850-6	14.89	15.20	3.96	135.3
857-15	14.70	14.80	3.56	131.8
828	13.50	13.58	2.34	120.9
56-408	15.10	13.52	2.28	120.3
US 41	13.30	11.24	----	100.0

Required for significance at 1% level 1.65 Tons

Table 2. VARIETY TEST WITH SELECTIONS FOR NEMATODE RESISTANCE IN FIELD HEAVILY INFESTED WITH SUGAR BEET NEMATODES, SALINAS, CALIFORNIA, 1960.

Selection	Plots Number	Acre yield Tons	Increase of Selection over US 41 Tons per acre	Percent of US 41
US 41	3	11.2	-	100.0
856-1	3	10.5	-	93.8
856-22	1	16.7	5.5	148.8
856-23	2	11.6	.4	103.6
861-2	1	15.1	3.9	134.8
861-3	1	16.7	5.5	148.8
861-4	1	13.3	2.1	118.6
861-6	1	14.1	2.9	125.5
861-7	1	8.3	-	74.1
861-8	2	16.9	7.5	150.9
861-10	1	14.6	3.4	130.2
861-11	1	14.1	2.9	125.2
861-13	1	12.5	1.3	111.6
861-14	1	12.8	1.6	113.9
861-15	1	10.9	-	97.3
861-17	1	20.3	9.1	181.3
861-18	1	15.9	4.7	141.9
861-19	1	13.9	2.7	123.7
861-20	1	12.5	1.3	111.6
861-21	1	13.0	1.8	116.3
861-22	1	13.0	1.8	116.3
861-24	1	14.3	3.1	127.9
861-25	2	13.3	2.1	118.6
861-26	1	17.7	6.5	158.0
861-27	2	17.1	5.9	152.7
803	1	10.4	-	92.9
803-2	1	15.6	4.4	139.3
803-3	1	15.6	4.4	139.3
832-7	2	15.1	3.9	134.8
834-1	2	17.5	6.3	156.3
834-2	2	15.1	3.9	134.8
836-1	2	12.3	1.1	109.8
836-2	2	14.6	3.4	130.4
836-3	1	10.9	-	97.3
857-1	1	14.6	3.4	130.2

Table 2 - Continued

Selection	Plots Number	Acre yield Tons	Increase of Selection over US 41 Tons per acre	Percent of US 41
857-2	1	15.9	4.7	141.9
857-3	1	36.5	25.3	225.9
857-4	2	14.6	3.4	130.4
857-5	1	20.8	9.6	185.7
857-6	1	12.2	1.0	109.3
857-7	1	16.4	5.2	146.4
857-8	1	12.2	1.0	109.3
857-9	1	12.8	1.6	113.9
857-10	1	17.7	6.5	158.0
857-11	1	11.7	.5	104.6
857-12	1	14.1	2.9	125.5
857-14	1	11.7	.5	104.6
857-15	2	24.8	13.6	221.4
857-16	1	14.8	3.6	132.5
857-17	1	16.2	5.0	144.2
857-18	1	14.3	3.1	127.9
804-2	1	17.7	6.5	158.0
859-2	1	13.9	2.7	123.7
859-3	1	17.7	6.5	158.0
859-4	1	13.0	1.8	116.3
859-5	1	13.5	2.3	120.9
859-6	1	14.3	3.1	127.9
859-7	1	16.9	5.7	150.9
859-8	2	22.8	11.6	203.6
801-1	1	14.8	3.2	132.5
801-2	1	20.8	9.6	185.7
801-3	1	23.7	12.5	211.6
801-4	1	13.0	1.8	116.3
801-5	1	14.3	3.1	127.9
801-6	1	12.5	1.3	111.6
801-7	1	20.8	9.6	185.7
801-8	1	16.2	5.0	144.2
801-9	1	16.2	5.0	144.2
801-10	1	10.9	-	97.3
801-11	1	12.8	1.6	113.9
801-12	1	17.5	6.3	156.3
801-13	1	17.7	6.5	158.0
801-14	1	12.8	1.6	113.9

Table 2 - Continued

Selection	Plots Number	Acre yield Tons	Increase of Selection over US 41 Tons per acre	Percent Of US 41
801-15	2	13.2	2.0	117.9
801-16	1	16.2	5.0	144.2
801-17	1	14.6	3.4	130.2
801-18	1	12.8	1.6	113.9
801-19	1	13.9	2.7	123.7
801-20	1	15.6	4.4	139.3
859	1	13.0	1.8	116.3
859-1	1	11.5	.3	102.7
860-3	2	12.9	1.7	115.2
860-4	2	16.8	5.6	150.0
860-7	1	17.7	6.5	158.0
802-1	1	13.5	2.3	120.9
802-3	1	13.0	1.8	116.3
802-5	1	14.6	3.4	130.2
802-6	1	14.1	2.9	125.5
802-7	1	15.9	4.7	141.9
802-8	1	15.4	4.2	137.1
802-9	1	20.8	9.6	185.7
802-11	1	14.6	3.4	130.2
802-12	1	12.0	.8	107.1
802-13	1	17.5	6.3	156.3
802-14	1	15.6	4.4	139.3
802-15	1	11.7	.5	104.6
802-18	1	10.9	-	97.3
802-19	1	14.1	2.9	125.5
802-20	1	9.9	-	88.4
802-21	1	12.0	.8	107.1
802-22	1	8.9	-	79.5
802-23	1	18.7	7.6	167.1
862-2	1	10.2	-	91.1
862-3	1	19.5	8.3	174.1
862-4	1	8.9	-	79.5
862-5	1	13.5	2.3	120.9
862-6	1	13.5	2.3	120.9
862-8	1	12.0	.8	107.1
862-9	1	16.7	5.5	148.8
862-14	1	13.9	2.7	123.7
863	1	15.4	4.2	137.1

Table 2 - Continued

Selection	Plots Number	Acre yield Tons	Increase of Selection over US 41 Tons per acre	Percent. of US 41
862	1	15.4	4.2	137.1
831-1	2	11.9	.7	106.3
889-1	2	13.6	2.4	121.4
833-3	3	18.3	7.1	163.4
850-1	2	13.0	1.8	116.3
850-2	1	11.5	.3	102.7
850-3	1	12.8	1.6	113.9
850-4	2	12.8	1.6	114.3
854-1s	2	11.2	.0	100.0
854-1	2	14.9	3.7	133.0
854-2s	2	10.8	-	96.4
854-2	2	16.4	5.2	146.4
835-1	1	14.6	3.4	125.5
862-7	1	20.8	9.6	185.7
862-11	1	14.3	3.1	127.9
862-13	3	16.6	5.4	148.2
862-15	3	13.8	2.6	123.2
871-13	3	15.2	4.0	135.7
892-5	3	13.5	2.3	120.5
899-11	3	14.5	3.3	129.5
828-10	3	12.3	1.1	109.8
832-8	1	10.4	-	92.9
863-8	1	16.2	5.0	144.2
863-9	1	13.0	1.8	116.3
835-2	1	15.6	4.4	139.3
835-3	1	13.5	2.3	120.9
824	4	11.2	0.0	100.0
875	3	13.5	2.3	120.5

relationships of the nematode to the plant and to its soil environment. Also, investigations of possible control measures, such as crop rotation, use of trap crops, and selection and breeding for resistance, are being conducted. Major emphasis is being placed on development of beet varieties having greater resistance to nematode damage by the author, but active cooperation with Arnold E. Steele of the Nematology Investigation, U.S.D.A. is being carried on. A brief outline of this cooperative work is reported under headings Microplots and Chemical Control.

Microplots. Small plots consisting of redwood bins have been designed to carry out limited field studies on the host parasite relationship of the sugar beet nematode and various crop plants. The microplots have been designed to afford a barrier to cross-contamination of plots as well as prevent experimental errors caused by unequal distribution of nematodes in the soil.

At present the microplots will be used to compare the effectiveness of trap crops in reducing nematode populations. The microplot tests will be preceeded by laboratory and greenhouse tests to determine the degree to which plant root diffusate stimulates larvae to hatch from nematode cysts. Other studies will be made to determine the extent to which nematodes penetrate plant roots and also if nematode development is arrested before the nematodes reach maturity.

It is believed that these studies will yield much information to growers on the effectiveness of various crops in reducing nematodes in the soil.

Chemical Control. An experiment was conducted at Spreckels Sugar Company experimental farm Salinas, California by Dr. C. W. McBeth,

Chief Nematologist, Shell Development Company, with Dr. Russell Johnson, Spreckels Sugar Company; Arnold E. Steele, U.S.D.A.; and Charles Price, U.S.D.A. cooperating. The object of the experiment was to determine the effect of nemagon in irrigation water flooded over the surface of the soil and held in the basin 45 minutes. The field selected for the test was uniformally infested with nematodes (255 cysts per 100 grams of soil). On March 24, 1960, the test plots were treated with 1.25 and 2.50 gallons per acre, respectively, with untreated plots as checks. All treatments were replicated 4 times. The treatment proceedure consisted of flooding the plots with 3 to 4 inches of water with or without nemagon. Nemagon was metered into the water by means of a gravity flow device. It was determined that the water penetrated the soil 8 inches deep. Sugar beet roots were taken from each of the test plots a month later and examined for the presence of nematodes. The average weight in grams per root for each treatment were as follows: Nemagon 2.5 and 1.25 gallons per acre and checks were 36.2, 67.0 and 150.5 grams respectively. There was a significant difference in weight per root between the 2.5 gallon application and check. At harvest however no significant difference in sugar content, weight of roots or stand count between the treatments was found.

It may be concluded that under the condition of this experiment Nemagon did not reduce the population of nematodes sufficiently to result in increased yields of sugar beets.

PART VI

VIRUS YELLOWS INVESTIGATIONS

and

BREEDING FOR YELLOWS RESISTANCE

Foundation Project 12

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PROJECT 12

YELLOWING OF SUGAR BEETS IN WESTERN UNITED STATES

C. W. Bennett

Introduction

Plants in fields of sugar beet in California are likely to begin to yellow any time after the middle of April. In some areas in central California, nearly all of the plants in many fields show yellowing by the middle of June. Beets show yellowing in western and central Oregon and in central Washington. Yellowing of foliage is common in the seed-producing areas of both Arizona and Oregon. Yellowing of beets is reported to be prevalent in some areas in Colorado. Utah, Idaho, and eastern Oregon have been practically free of yellows diseases in past years, but in 1959 yellow plants were found in certain fields in these areas.

The causes of yellowing of sugar beet have been under study in California since 1952, and during the past three years a more intensive effort has been directed toward the determination of the different entities involved and toward a more complete understanding of the relative importance of each entity involved.

When yellowing of beets in the United States was first reported by Coons (1) to be a virus disease, it was assumed that it was a disease similar to, or identical with, the disease of sugar beets in Europe designated "virus yellows". This conclusion was supported by vector and host range studies and by serological tests (2).

During the period of 1952-54 a number of isolations of virus were made from yellowed beets from southern California and the Salinas Valley. These isolations ranged in virulence from those which caused mild yellowing on sugar beet to those which caused vein clearing, severe yellowing, and necrosis. In the earlier studies the mild strains predominated and virulent strains were rarely encountered. In more recent years the reverse has been true.

During the past three years it has become evident that "yellows" viruses other than "virus yellows virus", infect sugar beet and that at least one of these is an important factor in the yellowing of sugar beets in western United States.

It has been recognized for some years that *Malva rotundifolia* (running mallow) and *M. parviflora* (little mallow) are generally infected throughout California with a type of yellows virus transmissible by the green peach aphids. It has not been found, however, that any of the known strains of virus (beet) yellows virus will infect either of these species. In earlier tests no symptoms were obtained in attempts

to transfer virus from mallow to sugar beet. More recently, however, Costa, Duffus, and Bardin (3) transmitted virus from mallow to beet under greenhouse conditions and obtained mild symptoms on beet. They also recovered the virus from field beets. The virus, however, causes little or no yellowing of beets under field conditions and it is not believed to be a factor in the yellowing of beets in California.

In 1960, Duffus (4) reported that a virus first obtained from radish causes a yellowing disease of radish and a number of other species of Crucifereae, as well as lettuce, spinach, and sugar beet. He found further that this virus is widely distributed in sugar beet plantings and that it causes a yellowing of beet that is distinguishable from the yellowing caused by the non-vein-clearing strains of the beet yellows virus. This virus appears not to be related to beet yellows virus. It differs in being persistent in the green peach aphid and in not attacking *Chenopodium amaranticolor*, *C. capitatum*, and New Zealand spinach. It also causes distinct yellowing on *Capsella bursa-pastoris* (shepherd's purse), which appears to be immune from strains of the beet yellows virus thus far isolated in the United States. This species, however, is reported to be susceptible to infection by beet yellows virus in Europe but symptoms consist largely of dwarfing rather than yellowing.

The disease described by Duffus (4) was first called "Radish Yellows", because the causal virus was isolated from radish. It has been found, however, widely distributed in sugar beets throughout much of western United States. On the basis of its distribution and the damage produced to sugar beet, this disease is now considered to be a major disease of sugar beet in western United States. Because of its importance on sugar beet and its widespread occurrence in the western part of north temperate zone of the western hemisphere, Duffus (5) has called the disease "Beet Western Yellows."

In this report the European type of yellows, sometimes known as "Virus Yellows", will be called "Beet Yellows" and the disease described by Duffus (4) will be called "Beet Western Yellows" or "Western Yellows."

Distribution of Yellows Viruses

During the past two years, efforts have been made to determine the factors involved in the yellowing of beets in as many areas of western United States as time and availability of material would permit. These tests have been made by selecting yellowed beets from different areas and by testing beets sent in by cooperating agencies. The tests were made by allowing nonviruliferous green peach aphids to feed on source plants and then transferring them to a series of differential host plants consisting of sugar beet, *Capsella bursa-pastoris*, *Chenopodium amaranticolor*, *C. capitatum*, and New Zealand spinach. Beet yellows virus

infects all of these species except _C. bursa-pastoris_. Severity of the effects on _C. capitatum_ and New Zealand spinach provides a measure of the virulence of the strain of the virus involved. The western yellows virus infects sugar beet and _C. bursa-pastoris_ but causes no injury to the other three species.

More than 200 plants were tested in 1959 and 304 plants were tested in 1960. These plants came from various parts of western United States and were selected because they showed yellowing of the type usually associated with beet yellows.

Beet yellows was found throughout California and in the Salt River Valley of Arizona. The recovered virus in most instances caused vein clearing on young beet leaves and necrosis and yellowing on older leaves. Mild strains of beet yellows virus were recovered more rarely.

Western yellows virus was recovered from all areas from which plants were tested. This virus now seems to be present in most of the beet-producing areas of western United States and in most of these areas more beets are infected by this virus than by beet yellows virus. High percentages of infection are indicated in all of the beet-producing areas of California. The virus appears to have been widespread in seed field in Oregon in 1959 and 1960. It has been recovered from plants from eastern Oregon, southern Idaho, Utah, and Colorado. Reports indicate, however, that in eastern Oregon, Idaho, and Utah, infection was limited and that yellowing did not appear until late in the season. It appears that no measurable damage was produced.

Damage caused by Two Types of Yellows

Tests were conducted in the greenhouse to obtain information on the relative effects of beet yellows and western yellows, singly and in combination, on growth and yield of a number of varieties and selections of sugar beets. Varieties and selections were planted in 6-inch pots and inoculated with the respective viruses when the plants were in about the 4-leaf stage. Virulent strains of both viruses were used. Sixty to 80 days after inoculations the beets were harvested and the roots were weighed.

There was a considerable range in severity of symptoms on the different selections; however, symptoms of western yellows were less severe than symptoms of beet yellows in all instances. Some selections showed severe top injury by the 2 viruses in combination, as indicated by the relative grades of severity in Table 1. Also, reduction in weight of roots was less in plants infected with western yellows than in plants infected with beet yellows. In the combination the reduction in root weight was more or less the sum of the damage caused by the

Table 1. Effect of western yellows and beet yellows singly and in combination on different selections of sugar beet under greenhouse conditions

Selection	Checks			Western yellows			Beet yellows			Western yellows + Beet yellows		
	No. of plants	Grade of severity [a]	Av. wt. roots Grams	No. of plants	Grade of severity [a]	Av. wt. roots Grams	No. of plants	Grade of severity [a]	Av. wt. roots Grams	No. of plants	Grade of severity [a]	Av. wt. roots Grams
US 75	80	-	33.7	40	1.0	34.2	38	2.0	31.8	40	1.6	32.8
US 75	45	-	35.6	55	1.3	34.7	57	2.2	33.4	55	2.5	32.4
F59-63H2	47	-	34.9	52	1.0	30.9	58	1.8	29.7	57	2.2	32.0
F58-86H7	53	-	34.2	52	1.0	30.3	60	2.1	24.4	60	3.6	18.2
F56-66H2	41	-	34.1	39	1.0	32.7	60	2.2	28.2	60	3.8	19.5
F59-63H4	41	-	35.2	56	1.0	36.9	60	1.6	29.9	60	2.4	30.2
F59-63H3	56	-	46.2	58	1.0	41.1	58	2.0	33.0	58	2.5	30.1
F59-63H1	59	-	41.5	60	1.1	40.4	59	2.8	34.8	60	2.9	33.2
US 201 B	28	-	32.7	40	1.0	30.6	38	2.2	24.6	38	3.1	16.8
512	58	-	45.8	59	1.3	45.6	55	2.1	41.5	59	2.6	41.2
IRS 4904	54	-	40.1	58	1.1	38.0	58	1.9	40.4	56	2.4	35.0
SL 9096	54	-	44.1	58	1.1	46.6	60	3.0	33.8	60	3.0	31.9
IRS 490 yy	58	-	-	58	1.8	-	60	2.6	-	59	3.1	-
Detroit Red	60	-	-	60	1.0	-	60	2.1	-	55	2.7	-
Early Blood Turnip Red	60	-	-	60	1.1	-	60	1.9	-	60	1.6	-
5511	55	-	26.2	57	1.1	27.1	58	3.0	17.5	59	3.0	17.4
57-EL-42S	60	-	54.3	60	1.0	51.8	60	1.8	42.5	60	1.8	40.7

[a] Grades are based on a scale of 5 in ascending order of severity.

two diseases separately, but in some instances it was slightly more. Whether this greater reduction in weight is significant remains to be determined.

The difference in symptoms produced on table beets (Detroit Red and Early Blood Turnip Red) by the two viruses is of special interest. Beet yellows increased the amount of anthocyanin and infected plants were dark red, whereas western yellows appeared to partially suppress anthocyanin formation and infected plants did not show as much red color as healthy check plants. Even plants with both viruses did not show as much red color as plants with beet yellows alone.

The damage produced by beet yellows alone and in combination with western yellows on a number of selections under field conditions is presented in the portion of this report on Project 12 dealing with breeding for yellows resistance. Evidence from both greenhouse and field tests indicates that western yellows causes less reduction in root weight than that caused by the more severe types of beet yellows.

Western yellows probably is less important also in seed production than beet yellows. Yellows apparently has caused no serious losses to the seed crop in Oregon, whereas in the Salt River Valley of Arizona evidence indicates that yields have been reduced appreciably over the past five years. This difference in damage may have resulted from the fact that yellowing of beets in Oregon has been caused largely by western yellows, whereas both western yellows and beet yellows have been involved in the damage produced in the Salt River Valley.

The effect of Previous Infection with Yellows Viruses on Susceptibility to Infection with Curly Top Virus

Tests by Giddings (6) indicated that plants infected with beet yellows may be more susceptible than yellows-free plants to infection with curly top virus. Also, some of the field observations at Riverside, California, have indicated that plants of certain selection were more susceptible to infection and injury if first infected with beet yellows virus.

To obtain further evidence on the effects of the presence of yellows viruses on susceptibility to curly top virus, greenhouse tests were made in which plants in pots were first inoculated with one or both of the yellows viruses in about the 4-leaf stage and then inoculated with curly top virus about 10 days after yellows symptoms were evident. The curly top inoculations were made by caging 1 viruliferous beet leafhopper on each plant for 7 days. Weak strains of the curly top virus were used to inoculate highly susceptible beet selections and more virulent strains were used for the more resistant selections.

Table 2. Effects of western yellows and beet yellows on susceptibility of beets to curly top.

Selection tested	Number of plants inoculated and infected following infection with indicated yellows virus on viruses							
	Checks [a]		Western yellows		Beet yellows		Western yellows + beet yellows	
	Inoc. No.	Inf. %	Inoc. No.	Inf. %	Inoc. No.	Inf. %	Inoc. No.	Inf. %
US 75	58	25.9	60	23.3	60	23.3	59	25.4
F59-63H2	57	33.3	60	20.0	59	23.7	60	16.7
F58-86H7	53	24.5	59	28.8	60	31.7	60	55.0
F56-66H2	60	11.7	60	13.3	60	25.0	60	45.0
F59-63H4	60	50.0	60	41.7	60	38.3	60	48.3
F59-63H3	60	11.7	60	13.3	59	15.3	58	29.3
F59-63H1	59	22.0	60	21.7	59	45.8	60	43.3
US 201-B	28	57.1	40	35.0	38	60.5	38	76.3
Detroit Red	60	61.7	60	70.0	60	68.3	55	65.5
512	60	23.3	59	28.8	59	39.0	59	40.7
IRS 4904	59	39.0	59	49.2	58	51.7	58	50.0
IRS 490 yy	58	29.3	58	29.3	60	55.0	59	67.8
5511	60	28.3	59	39.0	60	50.0	60	53.3
SL 9096	60	13.3	60	20.0	60	26.7	60	25.0

[a] Not inoculated with yellows virus.

The results of these tests (Table 2) perhaps are not sufficiently extensive to justify final conclusions with respect to the effects of yellows infection on subsequent susceptibility to curly top, but they do indicate a general trend that supports previous conclusions. Susceptibility to curly top appears not to be affected by presence of yellows viruses in some of the selections, whereas in others, susceptibility appears to be markedly increased. In some instances increase in susceptibility to curly top is greater with beet yellows and the combination of the two viruses than with western yellows.

Literature Cited

1. Coons, G. H. 1952. Virus yellows of beet in the United States. Plant Dis. Rep. 36: 356-363.
2. Coons, G. H. and J. E. Kotila. 1951. Virus yellows of sugar beets and tests for its occurrence in the United States. (Abstract) Phytopathology 41: 559.
3. Costa, A. S., James E. Duffus, and Roy Bardin. 1959. Malva yellows, an aphid-transmitted virus disease. Jour. Amer. Soc. Sugar Beet Tech. 10: 371-393.
4. Duffus, James E. 1960. Radish yellows, a disease of radish, sugar beet, and other crops. Phytopathology 50: 389-394.
5. Duffus, James E. Economic significance of beet western yellows (radish yellows) on sugar beet. Manuscript presented to Phytopathology for publication.
6. Giddings, N. J. 1954. Sugar beet virus yellows influences subsequent curly top infection. Amer. Soc. Sugar Beet Tech. Proc. (pt. 1) 8: 213-214.

BREEDING FOR RESISTANCE TO VIRUS YELLOWS

J. S. McFarlane, C. W. Bennett, and I. O. Skoyen

Selecting for Yellows Resistance

Selections for yellows resistance were made both in the greenhouse and field from segregating populations derived from crosses between plants selected for resistance in previous years. The greenhouse selections were from plants grown in six-inch pots and inoculated with a combination of beet and western yellows when the plants were six weeks old. The selections were based primarily on root size and were made when the plants were approximately four months old.

The field selections were from a three-acre plot which was planted in a checkerboard arrangement so that each plant occupied an area 28x28 inches. The planting was delayed until July 1 to permit the inclusion of seed from selections and crosses made in 1959. The plants were inoculated with a combination of beet and western yellows on August 15. Selections based on relative freedom from top symptoms and on root size were made November 10. A total of 1050 roots from 50 different segregating populations were selected and are now being thermally induced for seed production in the spring of 1961.

Effect of Two Yellows-Producing Viruses on Yields of Sugar Beet Hybrids and Their Parents

A field test to determine the interaction between varieties and two yellows-producing viruses was planted at Salinas on May 12, 1960. Included in five replications were four commercial hybrid varieties, four F_1 hybrids, a top-cross parent, and five inbred lines. To reduce border effects, the five inbred lines were planted as a group on one side of the test. The inbreds and hybrids were randomized within their respective groups.

The treatments, consisting of a noninoculated check, a beet-yellows inoculation, and a combination beet-yellows and western-yellows inoculation were arranged in randomized strips across each replication. The variety subplots were two rows wide and 35 feet long. Stands were excellent in the hybrids but somewhat irregular in the inbreds. To minimize the effect of irregular stands, the inbred subplots were thinned to approximately the same number of plants within each replication. The entire test was sprayed with Systox at ten-day to two-week intervals to control the aphid vectors of the yellows viruses. Spraying was started June 2 and continued to September 10.

Inoculations were made July 6 with a virulent strain of the beet-yellows virus and a combination of the beet-yellows and western-yellows viruses. The test was harvested November 1.

Infection ranging between 90 and 100 per cent was obtained in all inoculated plots. Yellows spread to the noninoculated plots late in the season but is thought to have caused little reduction in yield. Differences

in symtoms between plots inoculated with beet-yellows and with the combination of beet and western yellows were not apparent until about two and one-half months after inoculation. Beginning about September 20 the plots inoculated with the combination of viruses showed more severe necrosis and yellowing than did plots inoculated with beet yellows alone.

Rust infection was severe in the susceptible NB3 inbred and in MS of NB1 x NB3 during the last six weeks of growth. The inoculated plots were less severely infected than were the noninoculated plots. Rust undoubtedly caused some yield reduction in NB3 and in MS of NB1 x NB3 with the greatest loss occurring in the noninoculated plots.

Yields of the hybrids in the noninoculated plots ranged from 24.29 tons per acre for MS of NB1 x NB3 to 31.15 tons for US H5B (table 1). Beet yellows caused a reduction in root yields ranging from 18.3 to 26.7 percent. The difference between varieties was not significant. The yields of varieties inoculated with a combination of beet and western-yellows were reduced from 25.6 to 41.6 percent. This difference was significant at the one-percent point. The interaction between varieties and virus treatments (table 2) was significant at the five-percent point. This means that the hybrids and inbreds differed in their relative susceptibility to beet yellows and to the combination of beet and western yellows.

Yields of the inbred parents were lower than for the hybrids and the damage from the yellows viruses was more severe (table 1). Yields of the inbreds inoculated with beet yellows were reduced from 33.4 to 52.4 percent. This difference between inbreds was significant at the one-percent point. Yields of the inbreds inoculated with the virus combination were reduced from 40.0 to 54.8 percent, but this difference was not significant. The interaction between the inbreds and virus treatments (table 2) was significant at the one-percent point.

The results of this test showed that the effects of beet and western yellows were accumulative in most lines. However, the additional damage which resulted when western yellows was superimposed on beet yellows varied from one line to another. This was particularly true with the inbred lines. The yield of the yellows susceptible NB2 inbred was reduced 52.4 percent by beet yellows and 54.8 percent by the combination of beet and western yellows. With the somewhat more tolerant NB4 inbred the yield was reduced 33.4 percent by beet yellows alone and 46.2 percent by the virus combination.

Table 1.--Effect of beet yellows and of the combination of beet and western yellows on the root yield of sugar beet hybrids and their parents at Salinas, California. (Planted May 12 and harvested November 1, 1960.)

Variety No.	Description	Acre Yield: Check	Acre Yield: Beet Yel.	Acre Yield: Beet and West. Yel.	Reduction in yield: Beet Yel.	Reduction in yield: Beet and West. Yel.	Harvest Count: Check	Harvest Count: Beet Yel.	Harvest Count: Beet and West. Yel.
		Tons	Tons	Tons	Percent	Percent	Number	Number	Number
Varieties and hybrids									
F57-509H1	MS of NB1 x NB3	24.29	19.79	18.05	18.3	25.6	161	158	156
US H6	(MS of NB1 x NB5) x 663	29.31	22.38	19.71	23.1	32.6	154	154	154
F58-554H1	MS of NB1 x NB4	29.96	23.51	20.15	21.5	32.7	161	160	157
US H2	(MS of NB1 x NB3) x 663	27.25	30.38	18.25	24.5	32.9	146	149	149
F59-547H1	MS of NB1 x NB5	24.34	19.11	15.96	21.2	34.2	147	151	149
5511H1	MS of NB1 x NB2	26.58	19.43	17.36	26.2	34.5	146	143	144
US H4	(MS of NB1 x NB2) x 366	26.65	19.69	17.19	26.1	35.5	150	146	146
US H5B	(MS of NB1 x NB4) x 663	31.15	23.00	19.75	26.2	36.6	158	157	157
663	Top cross parent	27.93	20.47	16.29	26.7	41.6	153	149	146
	LSD at 5% point				NS	5.7		Beets per 100' row	
Inbred parents									
7547	NB5	17.18	11.04	10.26	35.7	40.0	119	115	117
5502H1	MS of NB1	20.95	13.73	11.67	34.0	44.2	108	117	113
F58-554	NB4	20.00	13.37	10.73	33.4	46.2	128	135	128
F59-509	NB3	8.13	4.79	3.62	40.6	54.5	82	85	78
5511	NB2	16.81	7.93	7.54	52.4	54.8	78	75	79
	LSD at 5% point				9.03	NS		Beets per 100' row	

Table 2.--Analysis of variance of root yields from field test to determine effect of yellows viruses on yields of sugar beet hybrids and their parents.

Variation due to	Degrees of freedom	Sum of squares	Mean Square	F value
Varieties and hybrids				
Varieties	8	368.37	46.05	18.80**
Replications	4	14.26	3.57	1.46
Error A	32	78.43	2.45	
Treatments	2	2,103.30	1,051.65	1,118.78**
Error B	8	7.49	0.94	
V x T	16	58.38	3.65	3.26*
Error C	64	71.66	1.12	
Total	134	2,701.89		
Inbred parents				
Varieties	4	950.67	237.67	65.12**
Rows	4	9.30	2.33	0.64
Columns	4	20.14	5.04	1.38
Error A	12	43.82	3.65	
Treatments	2	875.81	437.91	222.29**
Error B	8	15.73	1.97	
V x T	8	63.28	7.91	6.82**
Error C	32	37.19	1.16	
Total	74	2,015.94		

*Exceeds the 5-percent point
**Exceeds the 1-percent point

Yellows Resistance Evaluation Test

A field test was planted at Salinas on May 12, 1960, to determine progress made in selecting for beet-yellows resistance. The degree of resistance was determined by comparing inoculated and noninoculated plots of each variety or selection. Inoculations were made July 6 with a virulent strain of the beet-yellows virus by means of the green peach aphid.

Included in four replications were US 75, US 22/3, a greenhouse selection from US 22/3, a field selection from HC 1 made by J. E. Duffus and C. F. Lackey, and the third successive field selection from US 75. The plots were two rows wide by 35 feet long. Spraying to control the aphid vectors was started June 2 and continued to September 10. The test was harvested November 1.

Infection ranging between 90 and 100 per cent was obtained in all inoculated plots. Yellows spread to the noninoculated plots in three of the replications late in the season but is thought to have caused little reduction in yield. In the fourth replication, spread of yellows to the noninoculated plots occurred early in season and caused a reduction in yield. This replication was omitted from the analysis and summary table.

Root yields were reduced from 25.3 to 33.1 percent (table 3). The yield of the third successive selection from US 75 was reduced 25.3 percent compared to 31.7 percent for US 75. This difference of 6.4 percent was sufficient to demonstrate an improvement in resistance. The resistance of the HC 1 selection was no better than that of the closely related US 75 variety. The greenhouse selection from US 22/3 showed no improvement in resistance.

Table 3.--Effect of beet yellows on the root yield of sugar beet varieties and yellows tolerant selections at Salinas, California. (Planted May 12 and harvested November 1, 1960.)

Variety	Description	Acre Yield Check	Acre Yield Yellows	Reduction in yield	Harvest Count Check	Harvest Count Yellows
		Tons	Tons	Percent	Number	Number
911	Third sel. from US 75	28.34	21.15	25.3	167	164
015	Sel. from US 22/3	26.06	18.50	29.0	136	139
368	US 75	27.10	18.52	31.7	164	160
828	US 22/3	25.04	16.81	32.8	146	139
014	Sel. from HC 1	29.02	19.42	33.1	154	150
	LSD at 5% point	NS	2.32	4.8	Beets per 100' row	

Inheritance of Yellows Resistance

The field test to determine the interaction between varieties and yellows-producing viruses also provided an opportunity to study the inheritance of resistance. Comparisons of the yield depressions among four hybrid varieties and their parents (table 4) showed that the hybrid combinations were consistently less severely damaged than were the inbred parents. This relationship held true for both beet yellows and for the combination of beet and western yellows. A similar relationship between hybrids and their inbred parents was observed in 1958 and 1959.

Comparisons of the yield depressions of the inbred lines and of the F_1 hybrids involving these inbreds fail to give any clear cut information on the mode of inheritance of yellows resistance. The root yield of the hybrid between MS of NB1 and the susceptible NB2 inbred was reduced 26.2 percent when infected with beet yellows. The root yield of the hybrid between MS of NB1 and the somewhat tolerant NB4 inbred was reduced 21.5 percent. The difference in yield depression between these two hybrids was not significant.

When inoculated with a combination of beet and western yellows the F_1 hybrid between MS of NB1 and NB3 showed less damage than did the other three F_1 hybrids, even though the NB3 inbred was the most severely damaged of the four inbreds tested. The irregular behavior of MS of NB1 x NB3 probably resulted from protection to rust infection obtained in plants infected with yellows.

Table 4.--Percent reduction in the root yield of sugar beet hybrids and their parents at Salinas, California, in 1960.

Variety or Inbred	Description	Reduction in yield: Beet Yellows	Reduction in yield: Beet and West. Yel.
		Percent	Percent
US H2	(MS of NB1 x NB3) x 663	24.5	32.9
F59-509H1	MS of NB1 x NB3	18.3	25.6
5502H1	MS of NB1	34.0	44.2
F59-509	NB3 inbred	40.6	54.5
663	Top cross parent	26.7	41.6
US H5B	(MS of NB1 x NB4) x 663	26.2	36.6
F58-554H1	MS of NB1 x NB4	21.5	32.7
5502H1	MS of NB1	34.0	44.2
F58-554	NB4 inbred	33.4	46.4
663	Top cross parent	26.7	41.6
US H6	(MS of NB1 x NB5) x 663	23.1	32.6
F59-547H1	MS of NB1 x NB5	21.2	34.2
5502H1	MS of NB1	34.0	44.2
7547	NB5 inbred	35.5	40.0
663	Top cross parent	26.7	41.6
US H4	(MS of NB1 x NB2) x 366	26.1	35.5
5511H1	MS of NB1 x NB2	26.2	34.5
5502H1	MS of NB1	34.0	44.2
5511	NB2 inbred	52.4	54.8

COMPARATIVE EFFECTS OF THE BEET WESTERN YELLOWS AND BEET YELLOWS VIRUSES ON THE CONCENTRATION OF CERTAIN AMINO ACIDS IN SUGAR BEET

James E. Duffus and J. M. Fife

The beet Western yellows (radish yellows) virus, an entity capable of inducing foliage yellowing on sugar beet indistinguishable from that induced by some isolates of the beet yellows virus, is very prevalent in California beet growing areas (1). This virus alone and in combination with the beet yellows virus can cause serious losses in sugar production and is considered a major sugar beet disease (2).

Investigations have shown that changes in the concentration of certain amino acids take place in the leaves of sugar beet plants infected with the curly top virus (4) and also with the beet yellows virus (5). A ratio of the concentrations of certain of the amino acids which decrease to those that increase (aspartic acid plus glutamic acid/citrulline plus alanine) in plants infected with the beet yellows virus has been shown to have possible significance in selection of plants for resistance to the virus (5).

It was desirable to determine the effect of the Western yellows virus alone and in combination with the beet yellows virus on changes

in the concentration of selected amino acids and especially the effect on the previously mentioned amino acid ratio. The results of these investigations are presented in this report.

Methods

Leaf-tissue samples for amino-acid determinations were obtained from replicated field plots designed to determine the effects of the viruses on yield and sugar production. Plots were 30 feet long and 3 rows wide and were arranged in 4 latin squares. The 4 treatments on the US 75 sugar beets consisted of uninoculated (control) plots, plots inoculated with a fairly virulent isolate of the Western yellows virus, plots inoculated with a fairly virulent isolate of the beet yellows virus, and plots inoculated with both the Western and beet yellows isolates.

One leaf disk, 3/4 inch in diameter, was removed from each of 12 mature leaves from different plants selected at random from each of the plots. The disks, which were taken approximately 2 months after inoculation of the plots, were composited for each plot and quick-frozen. The juice was expressed from the frozen disks at a pressure of 5,000 pounds and was preserved in thymol and phenyl mercuric nitrate and stored at 10° F. The samples were thawed, shaken thoroughly, and centrifuged before aliquots were removed.

Concentrations of the amino acids were determined by single-dimensional paper chromatography by the ascending method on 9 x 11 inch Whatman No. 3 mm papers using a water-saturated phenol solvent. The techniques used were those described by Fife (5).

Results

The effects of the Western and beet yellows viruses on the content of certain amino acids are shown in Table 1.

Analysis of the aspartic acid and the glutamic acid data indicates a highly significant reduction in the concentration of these acids in the leaves of Western yellows and beet yellows affected plants. The interaction of the effects of the 2 viruses was also highly significant for both amino acids.

The factorial breakdown of the citrulline content analysis shows that the beet yellows virus affected the citrulline concentration much more than did the Western yellows virus. The interaction was significant only at the 5-percent level. The Duncan comparison (3) shows that both yellows viruses increased citrulline significantly. The beet yellows virus and the combination of beet yellows and Western yellows viruses significantly increased the citrulline content over the content for those beets infected with the Western yellows virus only.

The analysis of the data for the amino acid ratio (aspartic acid plus glutamic acid/citrulline plus alanine)shows a highly significant reduction in the ratio in both beet yellows and Western yellows affected plants. The interaction of the effects of the 2 viruses was also highly significant. The ratio in beets infected with both yellows viruses was significantly lower than in beets infected with the Western yellows virus alone.

TABLE 1. Effect of the Western Yellows and Beet Yellows Viruses on the Concentration of Certain Amino Acids in Leaves in Tests at Salinas, California. 1959.

Virus Used as Inoculum	Aspartic Acid (Mg per cent)	Glutamic Acid (Mg per cent)	Citrulline + Alanine (Mg per cent)	Ratio $\frac{\text{Aspartic Acid + Glutamic Acid}}{\text{Citrulline + Alanine}}$
None (control)	13.64^{A}	24.06^{A}	23.96^{Aa}	1.607^{Aa}
Beet Yellows Virus	4.71^{B}	10.73^{B}	79.31^{Bc}	0.208^{Bbc}
Western Yellows Virus	4.17^{B}	11.36^{B}	59.96^{Bb}	0.291^{Bb}
Beet Yellows Virus + Western Yellows Virus	3.89^{B}	11.06^{B}	95.56^{Bc}	0.194^{Bc}

A, B For a given trait, 2 means having any superscripts in common are not significantly different from each other at the 1% level.

a, b, c For a given trait, 2 means having any superscripts in common are not significantly different from each other at the 5% level.

The Western yellows and beet yellows viruses induced essentially the same qualitative effect on the amino acids studied in this experiment. The amino acid patterns induced by these 2 viruses were quite different from those induced by the curly top virus (4).

Significant differences were noted between isolates of the Western yellows and beet yellows viruses in relation to the concentration of citrulline in affected leaves. Whether reactions such as these may be used to distinguish between isolates of these viruses will be determined by further research, using different isolates of the viruses and studies of their effects on additional amino acids.

It is noteworthy that the interaction of the 2 viruses in regard to all the amino acids studied was significant.

The ratio of aspartic acid plus glutamic acid/citrulline plus alanine apparently is of little value in distinguishing between the beet yellows or Western yellows viruses. If, however, this ratio proves to be of value in indicating resistance of beets to the beet yellows virus, it may also indicate resistance to the Western yellows virus.

Summary

The concentration of certain amino acids in leaves of sugar beet plants infected with the Western yellows and beet yellows viruses was determined by paper chromatography. The concentration of aspartic acid and glutamic acid decreased essentially to the same extent in plants infected with either the Western yellows or beet yellows viruses.

Citrulline plus alanine was increased in plants infected by either virus. The beet yellows virus, however, affected the concentration of these amino acids to a greater extent than the Western yellows virus. The interaction of the 2 viruses in regard to all of the amino acids studied was significant.

Literature Cited

1. Duffus, James E. 1960. Radish yellows, a disease of radish, sugar beet and other crops. Phytopathology. 50: 389-394.
2. Duffus, James E. 1961. Economic significance of beet Western yellows (radish yellows) on sugar beet. Manuscript presented to Phytopathology for publication.
3. Duncan, D. B. 1955. Multiple range and multiple F. tests. Biometrics 11: 1-42.
4. Fife, J. M. 1956. Changes in the concentration of amino acids in the leaves of sugar beet plants affected with curly top. Proc. Amer. Soc. Sugar Beet Tech. 9: 207-211.
5. Fife, J. M. 1960. Changes in the concentration of amino acids in sugar beet plants induced by virus yellows. Jour. Amer. Soc. Sugar Beet Tech. (In press).

PROJECT 12

BREEDING FOR RESISTANCE TO VIRUS YELLOWS BY SELECTION OF INDIVIDUAL PLANTS HAVING A FAVORABLE AMINO ACID RATIO IN THE LEAVES OF INFECTED PLANTS

by

J. M. Fife

Introduction

Investigations have shown that the amino acid pattern is greatly altered in the mature leaves of sugar beet plants showing the chronic symptoms of virus yellows. In some plants, the concentration of aspartic and glutamic acids are reduced as much as 60 percent, while the concentration of citrulline plus alanine may be doubled. In the mature leaves of healthy plants, the amino acid ratio $\frac{\text{aspartic} + \text{glutamic}}{\text{citrulline} + \text{alanine}}$ was found to vary from 1.0 to 3.0 depending upon the fertility and other conditions. Under the same conditions, in leaves of some plants showing the chronic symptoms, the ratio may be as low as 0.5 or even lower. A wide variation in the amino acid ratio was found to occur among plants of the same variety growing under the same nutritional conditions. These observations suggested that plants having resistance to virus yellows may be identified by the degree to which the amino acid ratio is altered in mature leaves of plants inoculated with a severe strain of the yellows virus.

This report is concerned with the methods used in making selections for resistance to sugar beet yellows and tests in which certain of the selections are compared with the parent in the field and under greenhouse conditions.

Materials and Methods

Approximately 1000 plants (variety US 75) were grown in sand and watered with Hoagland's solution. The plants were inoculated in the 4- to 6-leaf stage and 5 weeks later two mature leaves, showing the chronic symptoms of the disease, were removed from each plant and the concentration of certain amino acids determined by paper chromatography. The plants having an amino acid ratio greater than the mean for the group by at least twice the standard deviation were selected. Of these plants, a further selection was made. Plants whose roots were smaller than the mean were discarded. Only 10 plants having a superior amino acid ratio and a root weight equal to or greater than the mean made up a polycross for seed increase. The seed from each plant was kept separate, thus making each of the 10 selections originating from a single plant progeny.

From the same 1000 plants, grown in sand culture as described, a second selection was made. Plants having roots weighing greater than the mean by at least twice the standard deviation were selected. Of the plants selected, those having an amino acid ratio less than the mean were then discarded. Twenty eight plants, having a superior root weight and an amino acid ratio equal to or greater than the mean for the 1000 plants tested, made up a second polycross for seed increase. The seed from each plant was kept separately, thereby making each selection originating from a single plant progeny.

A preliminary test was conducted in which the 28 selections and the parent were tested in the greenhouse. The plants were inoculated in the 4-leaf stage with a severe strain of the yellows virus. The root weight and the amino acid ratio of each individual plant was determined after a growing period of 94 days following emergence.

Of the 28 selections tested in the greenhouse, 11 were tested further, using inoculated plants grown in the greenhouse and in the field.

The results of these tests are summarized in this report.

Results

Seeds of 6 of the selections and the parent (US 75) were planted in flats in the greenhouse. Three days after emergence, the seedlings were transplanted to aluminum cylinders 2-1/2" by 4" high and placed outside to harden off after they had become established. The plants, in the 4-leaf stage, were transplanted to the field on May 17, in the following manner. Plants of one selection were transplanted alternately in a row with plants of the parent, using a 6-inch spacing. The six selections were transplanted in the above manner, with each selection occupying a separate row with the parent. By alternately transplanting plants of the selection and the parent in the same row, the variation in soil fertility was eliminated.

On the above date, seeds of 5 other selections and the parent were planted, each in separate rows, adjacent to the transplanted selections. Ten days later the transplanted plants were inoculated with a severe strain of the yellows virus. The plants grown from seed, in the field, were thinned to a spacing of 6 to 8 inches and upon reaching the 4-leaf stage were inoculated with the same strain of the yellows virus.

After 152 days from emergence, the transplanted plants were harvested. Each individual root was weighed and its sucrose determined. The results of tests for the transplanted selections is shown in table 1. In view of such a short growing period, 152 days from emergence, the selections made excellent yields. Every selection was superior to the parent, with four of the selections being superior at the 1% level. The two selections whose root weights were significant only at the 5% level showed a significant increase in the percentage sucrose in the roots--one at the 1% level.

Table 1

Field test of sugar beet selections, for resistance to virus yellows, made by transplanting plants of the parent (US 75) and of one selection alternately in the same row, using a six-inch spacing.

Selection	Selection Made on Basis of	Roots Tested	Acre Yield Beets	Acre Yield Gross Sugar	Increase Over Parent Beets	Increase Over Parent Gross Sugar	Sucrose
		No. 1/	Tons	Pounds	%	%	%
91DS-3	Root Wt.	46	43.85**	11,418**	99.5	109	13.02*
US 75		49	21.99	5,466			12.43
91DS-24	Root Wt.	45	23.27*	6,188**	24.5	35.4	13.51**
US 75		50	18.39	4,572			12.43
91DS-23	Root Wt.	44	25.41*	6,672**	22.9	29.8	13.13*
US 75		50	20.68	5,140			12.43
91DR-6	Ratio 2/	48	23.61**	5,752**	48.7	45.8	12.18
US 75		50	15.87	3,946			12.43
91DS-9	Root Wt.	44	32.62**	8,012**	50.3	48.5	12.28
US 75		50	21.27	5,396			12.43
91DS-22	Root Wt.	48	26.62**	6,746**	63.7	66.9	12.67
US 75		50	16.26	4,042			12.43

1/ Each root considered a replication.

2/ Concentration of amino acids determined in the mature leaves of beet plants inoculated with a severe strain of the yellows virus.

$$\text{Ratio: } \frac{\text{Aspartic acid} + \text{Glutamic acid}}{\text{Citrulline} + \text{Alanine}}$$

* Significantly greater than the parent at the 5% level.

** Significantly greater than the parent at the 1% level.

From this test, selection 91DS-3 appeared to be very outstanding. The yield of this selection was double that of the parent, when they both were growing alternately in the same row. It also showed a significant increase in the percentage sucrose. All selections were superior to the parent in gross sugar per acre, being significant at the one-percent level.

The selections, grown from seed in the field (table 2), made a favorable growth despite the short growing season of only 124 days from emergence. The yields of two of these selections were superior to the parent. One selection, 91DS-7, showed a significant increase in percentage sucrose, being significant at the 1% level. Although the yield of roots of this selection failed, by a narrow margin, to reach significance, the increase in sucrose percentage in the roots was sufficient to give a highly significant increase in gross sugar per acre.

The selections, listed in table 1, were tested further, by growing the plants in 6-inch pots in and outside the greenhouse. Table 3 shows the mean weight of the roots and the percent increase in weight over the parent (US 75) for the tests conducted in pots. The field test is also included, which summarizes all of the tests conducted using the selections in question. The percentage increase in weight over the parent of selection 91DS-3 for the two pot tests agreed very closely. This selection made even a better showing in the field, being double that of the parent when growing alternately in the same row. Selections 91DS-24 and 91DS-23 showed a greater increase in weight over the parent in the pot tests than they did in the field. The percentage increase in weight of selections 91DS-9 and 91DS-22 for the pot tests and the field tests was approximately the same in each case. Selection 91DR-6 showed no improvement in root weight over the parent in the pot test in the greenhouse; however, under field conditions, this selection was superior to the parent.

Discussion

The observation that as many as 4 selections, of the 11 tested, showed a superior sucrose content over that of the parent without loss in tonnage is strong evidence that some of the selections may have a significant degree of resistance to sugar beet yellows. Bennett reports (Tech. Bul. 1218) that, "in plot tests in the Salinas Valley in 1955, natural infection caused a reduction in tonnage of 22.3 percent and a reduction in sucrose of 1.38 percentage points". The 4 selections, with all plants inoculated with a severe strain of the virus, showed a mean increase in sucrose of 0.86 percentage points over that of the parent. The gain in root weight, of 4 of the 6 selections (table 1) over that of the parent, was much more than required to make up for a loss equal to the 22.3 percent loss due to

Table 2

Field test of sugar beet selections, for resistance to virus yellows, by planting seed of the parent (US 75) and the selections in adjacent rows with plants thinned to a spacing of six to eight inches.

Selection	Selection Made on Basis of	Roots Tested	Acre Yield: Beets	Acre Yield: Gross Sugar	Increase Over Parent: Beets	Increase Over Parent: Gross Sugar	Sucrose
		No. 1/	Tons	Pounds	%	%	%
US 75		108	18.79	5,088			13.54
91DS-7	Root Wt.	102	21.53	6,192**	14.6	21.7	14.38**
91DR-7	Ratio 2/	64	25.11**	6,754**	33.7	32.7	13.45
91DS-19	Root Wt.	102	21.37	5,838	13.7	14.7	13.66
91DR-3	Ratio	76	22.22*	6,084*	18.3	19.6	13.69
91DR-4	Ratio	63	20.52	5,454	9.2	6.8	13.29

1/ Each root considered a replication.

2/ Concentration of amino acids determined in the mature leaves of beet plants inoculated with a severe strain of the yellows virus.

$$\text{Ratio: } \frac{\text{Aspartic acid} + \text{Glutamic acid}}{\text{Citrulline} + \text{Alanine}}$$

* Significantly greater than the parent at the 5% level.

** Significantly greater than the parent at the 1% level.

Table 3

Summary of greenhouse and field tests of six sugar beet selections made for resistance to yellows.

Selection	Exp. No.	Location and Conditions of Test	Plants Used	Root Wt.	Increase Over Parent (US 75)
			No. 1/	Grams	Percent
91DS-3	329	Pots in greenhouse	24	55.6**	53.2
	344	Pots outside	126	42.7**	58.1
	346	Transplants to field	46	1065.4**	99.5
91DS-24	329	Pots in greenhouse	24	55.1**	51.8
	344	Pots outside	126	40.1**	48.5
	346	Transplants to field	45	565.4*	24.5
91DS-23	329	Pots in greenhouse	24	54.9**	51.6
	344	Pots outside	124	46.8**	73.3
	346	Transplants to field	44	617.3*	22.9
91DS-9	329	Pots in greenhouse	24	56.6**	51.0
	344	Pots outside	126	48.1**	68.1
	346	Transplants to field	44	792.7**	50.3
	351	Pots outside	28	27.4**	40.7
91DS-22	329	Pots in greenhouse	24	66.6**	83.5
	346	Transplants to field	48	646.8**	63.7
91DR-6	329	Pots in greenhouse	41	40.6	11.8
	346	Transplants to field	48	573.6**	48.7

1/ Each root considered a replication. Number of roots of parent equal to, or greater than, selection in same test.

* Significantly greater than the parent at 5% level.

** Significantly greater than the parent at the 1% level.

yellows in the field plots in 1955. It would appear from these tests that some of the selections have greater vigor than the parent under conditions of severe yellows. This greater vigor was not demonstrated in a significantly greater top growth but only in a greater rate of root growth during the short growing period under severe yellows conditions.

Extensive field and greenhouse tests are being conducted to determine the degree of resistance to sugar beet yellows, and other favorable characters these selections may possess.

PART VII

DEVELOPMENT AND EVALUATION
of
INBRED LINES AND HYBRID VARIETIES OF SUGAR BEETS SUITABLE FOR CALIFORNIA

Foundation Projects 24 and 29

J. S. McFarlane
B. L. Hammond
I. O. Skoyen
K. D. Beatty

Cooperators conducting tests:

American Crystal Sugar Company
Holly Sugar Corporation
Spreckels Sugar Company
Union Sugar Division
Southwestern Irrigation Field Station

REPORT ON FOUNDATION PROJECTS 24 AND 29

Summary of Accomplishments

J. S. McFarlane

BOLTING RESISTANCE.--The 1959-60 season was favorable for the induction of bolting at Salinas and the resistance of new breeding lines was determined. More than 200 monogerm inbreds were included in a September 11, 1959, planting and several remained completely vegetative. Bolting-resistant commercial varieties included in the same test bolted from 12 to 50 percent.

Additional bolting resistance information was obtained from a November 12 and a December 16 planting at Salinas. A higher percentage of bolting occurred in the December planting than in the November planting. The incidence of yellows was higher, and infection occurred earlier in the November planting and is thought to have been the cause of reduced bolting. Bolting resistance information was also obtained by Dr. Don Dickenson from a planting made at Tracy on September 30 and by Union Sugar from a variety test planted at Betteravia on January 8. Bolting percentages of US hybrids and the US 75 variety summarized from these tests follow:

		Salinas			Betteravia	Tracy
Variety	Description	9/11	11/12	12/16	1/8	9/30
887H5	(6x5) x 787	16.9	1.0	1.4	0.6	--
368	US 75	12.1	1.7	4.9	1.1	8.1
US H6	(1x5) x 663	28.3	4.4	5.8	3.4	13.5
F59-63H4	7569HO x 663	15.0	6.1	4.3	3.7	15.0
US H5A	(1 x 4) x 586	27.6	5.2	6.3	2.4	9.9
US H5B	(1 x 4) x 663	38.7	6.9	12.8	5.5	6.8
US H3	(1 x 3) x 586	36.1	--	--	--	16.9
US H2	(1 x 3) x 663	50.6	--	--	--	23.0
L.S.D.	(5%)	13.5	2.0	3.8	1.6	--

MILDEW RESISTANCE.--Downy mildew did not occur in any of the Salinas tests in 1959-60. Backcrossing was continued to incorporate the mildew resistance of the 8503 multigerm line into monogerm inbreds.

SEED LOTS MADE AVAILABLE THROUGH THE FOUNDATION.--A new monogerm inbred, 0562, and its male sterile, 0562HO, were made available in 1960. This inbred is an increase of an F_3 selection from a cross between NB1 and the bolting resistant 8507 monogerm. It is a sister line of 9561 which was made available in 1959. In the 1959 and 1960 tests, 0562 showed good resistance to both bolting and curly top. It tends to be low in vigor and may be a little difficult to handle in the seed field. The first combining-ability information will be available from an Imperial Valley test to be harvested in April 1961. The male sterile, 0562HO, represents the second back-cross to 0562 type monogerms.

A new multigerm inbred, 0539, has been made available for seed increase. This is an S_4 line from a cross between a Type O selection from US 56 and the NB1 inbred. It has very good curly-top resistance and moderate bolting resistance. Combining-ability tests indicate that 0539 performs well as a pollen parent in combination with monogerm male sterile parents.

EVALUATION TESTS WITH MONOGERM HYBRIDS.--Testing was continued with the monogerm hybrid (MS of 7515 x 7569) x 663. In 23 tests conducted in all parts of the State by the USDA and the sugar companies, this hybrid produced a gross sugar yield which averaged 109 percent of US 75. The sucrose percentage averaged 102 percent of US 75. In 1959 the gross sugar yield of this hybrid averaged 115 percent and the sucrose percentage 104 percent of US 75 in 11 tests. It has good bolting resistance and is intermediate between US 56 and US 75 in curly-top resistance.

Preliminary results with the hybrid (MS of 7515 x 7569) x 0539 have been most encouraging. In seven 1959 and 1960 tests the gross sugar yield of this hybrid averaged 121 percent and the sucrose percentage 103 percent of US 75. This performance is equal to that of the best multigerm hybrids.

Seed of each of the parental components of these monogerm hybrids has been made available through the Foundation. The inbred 7515 and its male sterile equivalent are difficult to reproduce, and elite seed increases are being attempted in 1960-61 at both Medford and Salem.

Combining tests with 9561, the monogerm inbred made available in 1959, proved somewhat disappointing. In seven tests the gross sugar yield of F58-85HO x 9561 averaged 105 percent and the sucrose percentage 102 percent of US 75. Additional information on the combining ability of 9561, particularly when used as a component of the male-sterile parent, is needed before it is used commercially.

US H6 HYBRID.--A new hybrid variety with the parentage (MS of NB1 x NB5) x 663 has been designated US H6. This hybrid has been tested four years and has performed well in the Coastal valleys and in the Imperial Valley. Curly-top resistance is similar to that of US H2, and bolting resistance is slightly inferior to that of US 75. A summary of the performance of US H6 expressed in percent of the performance of US 75 follows:

	Coastal district			Imperial Valley		
Year	No. of tests	Gross sugar	Sucrose percentage	No. of tests	Gross sugar	Sucrose percentage
1957	8	117	105	3	114	102
1958	8	115	103	-	-	-
1959	6	115	102	2	120	102
1960	12	118	102	10	116	100

The US H6 hybrid is recommended for September plantings in the Imperial Valley and for winter plantings beginning December 15 in the Coastal valleys. It can also be used for early plantings in the Sacramento and San Joaquin Valleys.[1]

POLYPLOIDY.--Increased emphasis was placed on polyploid breeding during 1960. This was made possible by the addition of Dr. Bayard Hammond to our staff. Dr. Hammond has checked chromosome numbers in tetraploid lines of NB1 and other inbreds which were identified in previous years on the basis of pollen size and chloroplast counts. He has also produced tetraploids in the 663 top cross parent and in two of the more promising monogerm lines. A summary of this work, prepared by Dr. Hammond, is included in this report, page 187.

An extensive evaluation program with triploid hybrids between our diploid male steriles and tetraploids developed in England and Sweden was carried out in 1960. This work, which is summarized in a separate section of this report, showed that the yields of the best triploid hybrids were equal or possibly slightly superior to the yields of our best diploid hybrids. None of the triploids showed superiority to the better diploid hybrids in sucrose percentage.

TYPE O SELECTIONS.--Indexing work was continued to develop Type O monogerm breeding lines. Mr. Skoyen classified 223 index progenies during the spring and summer of 1960. He also produced 172 index crosses during 1960 and is classifying the progenies of these crosses in the greenhouse at the present time.

[1] Summaries of performances of US H2, US H3, US H4, US H5 A, and US H5 B, for 1957, 1958, and 1959, are given on page 137; and for 1960, on pages 138-141.

Descriptions of Varieties Included in Summary Tables

Multigerm hybrids

US H2	(MS of NB1 x NB3) x 663
US H3	(MS of NB1 x NB3) x 586
US H4	(MS of NB1 x NB2) x 366 and 586
US H5A	(MS of NB1 x NB4) x 586
US H5B	(MS of NB1 x NB4) x 663
US H6	(MS of NB1 x NB5) x 663
887H5	(MS of NB6 x NB5) x 787
9561H4	(MS of NB1 x NB3) x 9561
9561H5	F57-85HO x 9561

Monogerm hybrids

F59-63H4	(MS of 7515 x 7569) x 663
886H1	(MS of 7515 x 7569) x 586
887H1	(MS of 7515 x 7569) x 787
8539H2	(MS of 7515 x 7569) x 8539

PURITY ANALYSES, OXNARD, BETTERAVIA, KING CITY VARIETY TESTS, 1960

By Union Sugar Division

Variety No.	Description	Thin juice purity: Oxnard	Betteravia	King City Test 1	King City Test 2
		Percent	Percent	Percent	Percent
F59-63H3	US H5B	75.7	87.9	90.2	
787H1	(MS of NB1 x NB4) x 787			89.8	
F59-63H1	US H2			89.8	
F59-86H3	US H5A	76.8	88.3	90.1	
F59-63H2	US H6	74.1	87.2	90.9	
9921H1	(MS of NB1 x NB3) x H3611			89.7	
F59-63H4	8569H1 x 663	75.1	87.9	89.9	
E-67	TASCO [redacted] Hybrid			90.8	
9561H5	F57-85H0 x 9561	75.4	86.8	90.8	
9921H3	7569H0 x H3611	74.0	87.2	89.4	
368	US 75	74.9	87.5	88.6	88.8
9561H4	(MS of NB1 x NB3) x 9561			90.1	
9921H2	(MS of NB1 x NB4) x H3611	74.1	87.5		89.8
863H5	7503H1 x 663	74.5	85.6		90.1
887H5	(MS of NB6 x NB5) x 787	75.5	86.6		89.4
9953-6	7569H0 x E10				90.7
8539H2	7569H0 x 8539				90.9
9953-2	7569H0 x D13				90.5
9952-2	(MS of NB1 x NB4) x D13				89.6
9952-4	(MS of NB1 x NB4) x D38				89.8
F58-86H7	US H3				91.9
F56-66H2	US H4				89.8
1-300	Klein E				90.1
General MEAN of all varieties in test		75.0	87.2	90.0	90.1
S. E. of MEAN		2.62	0.96	0.61	0.55
Significant Difference (19:1)		N.S.	N.S.	N.S.	N.S.
S. E. of MEAN in % of MEAN		3.49	1.10	0.68	0.51

PURITY ANALYSES FOR CENTRAL VALLEY AND IMPERIAL VALLEY, CALIFORNIA VARIETY TESTS, 1960

By Holly Sugar Corporation

Variety No.	Description	Thin juice purity							
		Tracy	Gerber	So. San Joaquin (Fall)	So. San Joaquin (Spr.)	Ryer Island	Staten Island	Hamilton City	Imperial Valley I.P.D.[1/]
		Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Lot 9381	US H2	94.35	88.38	83.07	87.87	87.35	88.58	90.93	92.04
Lot 9354	US H4	94.22	87.72	82.89	87.22	87.23	88.28	91.58	92.21
Lot 813	US 75	93.79	86.97	80.89	86.59	86.04	88.87	90.48	90.63
Lot 819	US 56/2	--	--	--	--	--	--	--	91.88
F57-86	Bolt. res. sel. US 35	93.90	--	--	86.45	--	--	--	90.41
663H2	US H6	--	--	--	87.65	--	--	--	--
863H8	7569HO x 663	93.94	--	--	88.01	--	--	--	--
F59-63H4	7569HO x F57-63	93.57	--	--	--	87.73	--	--	--
886H1	7569HO x 586	--	--	--	86.76	--	88.53	--	--
886H5	(MS of NB6 x NB5) x 586	--	--	80.77	--	--	--	--	91.41
887H1	7569HO x 787	--	--	83.47	--	86.06	88.42	90.44	--
887H5	(MS of NB6 x NB5) x 787	--	--	80.91	87.77	--	--	--	91.10
9561H4	(MS of NB1 x NB3) x 9561	94.38	--	--	--	--	89.02	--	91.02
9561H5	F57-85HO x 9561	--	--	--	--	--	--	--	90.31
9921H1	(MS of NB1 x NB3) x H3611 (3n)	--	--	--	--	--	--	89.50	--
9921H2	(MS of NB1 x NB4) x H3611 (3n)	--	--	--	--	--	--	87.53	--
9921H3	7569HO x H3611 (3n)	--	--	--	--	--	--	89.15	--
General MEAN of all varieties in test		93.89	88.03	82.49	87.38	86.72	88.39	90.42	91.40
S. E. of MEAN		0.20	0.49	0.76	0.69	0.53	0.61	0.40	0.33
Significant Difference (19:1)		0.55	N.S.	2.14	N.S.	N.S.	N.S.	1.11	0.93
S. E. of MEAN in % of MEAN		0.21	0.55	0.92	0.79	0.61	0.69	0.44	0.36

1/ I.P.D. = Intermediate Planting Date.

Beet Seed Breeding Department
Holly Sugar Corporation

A summary of the results with the US hybrids for the period of 1957-59 is shown in the following table: 1/

Variety	Year	Number of tests 2/			Performance in % of US 75					
					Gross Sugar Yield			Sucrose Content		
		C	CV	IV	Coast	Cent.Val.	Imp.Val.	Coast	Cent.Val.	Imp.Val.
US H2	1957	3	4	3	113	123	118	104	105	103
	1958	5	3	7	111	104	124	102	101	101
	1959	2	12	8	124	121	118	102	105	102
US H3	1957	4	4	2	107	101	108	107	106	104
	1958	5	1	7	96	96	106	103	107	104
	1959	2	7	7	111	104	111	104	107	105
US H4	1957	4	3	1	109	113	113	107	107	111
	1958	5	1	6	113	101	105	107	106	105
	1959	1	11	6	107	111	115	105	109	108
US H5A	1958	8	1	7	113	103	115	102	99	100
	1959	5	0	1	108	-	114	102	-	101
US H5B	1959	8	2	2	116	126	119	101	99	101

1/ Summary Table from Sugar Beet Research, 1959 Report, page 118.

2/ C = Coastal Districts; CV = Central Valley; IV = Imperial Valley.

Gross sugar yields of bolting-resistant hybrids in 1960
California variety tests, expressed in percent of the yield of US 75

Location	Testing Agency	US 75	US H2	US H3	US H4	US H5A	US H5B	US H6	887H5	9561H4	9561H5	F59-63H4	886H1	887H1	8539H2
Coastal Area															
Salinas	USDA	100	-	-	-	115	128	129	114	115	-	120	-	-	132
Salinas	Union	100	113	99	103	117	108	114	112	90	108	108	-	-	119
King City	"	100	122	108	106	117	124	117	106	95	112	115	-	-	119
San Ardo	"	100	107	102	106	101	109	111	103	90	102	107	-	-	-
Betteravia	"	100	-	-	-	113	124	122	101	-	107	111	-	-	-
Oxnard	"	100	-	-	-	107	115	112	105	-	93	96	-	-	-
Alisal	Spreckels	100	109	-	-	-	113	115	-	-	-	-	99	-	-
Salinas	"	100	-	-	-	-	113	113	-	-	-	102	-	-	-
Spreckels	"	100	110	-	-	113	123	121	110	-	-	116	109	-	-
"	"	100	116	-	-	-	121	125	-	-	-	-	-	-	-
Hollister	"	100	-	-	-	-	-	122	-	-	-	110	-	-	-
Gilroy	"	100	102	-	-	98	-	-	-	-	-	105	84	-	-
Watsonville	"	100	-	-	-	-	119	110	-	-	-	106	-	-	-
Central Valley															
Tracy	Holly	100	116	-	104	-	-	-	-	90	-	102	-	-	-
Gerber	"	100	101	-	97	-	-	-	-	-	-	-	-	-	-
So. San Joaquin, Fall	"	100	145	-	133	-	-	-	123	-	-	-	-	129	-
So. San Joaquin, Spr.	"	100	128	-	108	-	-	116	115	-	-	113	112	-	-

Gross sugar yields of bolting-resistant hybrids in 1960
California variety tests, expressed in percent of the yield of US 75
(Continued)

Location		US 75	US H2	US H3	US H4	US H5A	US H5B	US H6	887H5	9561H4	9561H5	F59-63H4	886H1	887H1	8539H2
Central Valley (Cont'd)															
Ryer Island	Holly	100	117	-	108	-	-	-	-	-	-	109	-	107	-
Staten Island	"	100	115	-	107	-	-	-	-	115	-	-	96	112	-
Hamilton City	"	100	105	-	105	-	-	-	-	-	-	-	-	95	-
Five Points	Spreckels	100	-	-	-	-	-	151	131	-	-	-	-	-	-
Dos Palos	"	100	131	-	-	-	-	-	-	-	-	-	-	-	-
Mendota	"	100	-	-	-	108	-	122	127	-	-	-	-	-	-
Imperial Valley															
Brawley - Early	USDA	100	123	106	103	115	123	117	-	114	102	112	102	107	127
" - Late	"	100	142	129	127	131	-	139	-	-	-	127	-	-	-
Imp. Val. - Early	Holly	100	110	-	105	-	-	105	-	-	-	91	93	98	-
" " "	"	100	118	-	112	-	-	118	-	-	-	98	100	101	-
" " "	"	100	116	-	117	-	-	114	-	-	-	105	94	99	-
" " "	"	100	121	-	119	-	-	103	-	-	-	107	107	103	-
" " - Late	"	100	110	-	107	-	-	113	-	-	-	101	95	101	-
" " "	"	100	115	-	112	-	-	113	-	-	-	109	101	105	-
" " "	"	100	118	-	116	-	-	117	-	-	-	117	106	106	-
" " "	"	100	132	-	112	-	-	123	-	-	-	130	112	129	-
" " - Inter.	"	100	112	-	117	-	-	-	108	107	110	-	-	-	-

Sucrose percentage of bolting-resistant hybrids in 1960
California variety tests, expressed in percent of US 75

Location	Testing Agency	US 75	US H2	US H3	US H4	US H5A	US H5B	US H6	887H5	9561H4	9561H5	F59-63H4	886H1	887H1	8539H2
Coastal Area															
Salinas	USDA	100	-	-	-	103	101	102	101	103	-	103	-	-	103
Salinas	Union	100	102	97	102	102	103	102	102	99	103	102	-	-	99
King City	"	100	108	109	108	110	106	107	101	101	108	107	-	-	101
San Ardo	"	100	98	102	105	101	101	99	95	98	101	102	-	-	-
Betteravia	"	100	-	-	-	107	102	103	93	-	97	98	-	-	-
Oxnard	"	100	-	-	-	109	103	98	102	-	98	96	-	-	-
Alisal	Spreckels	100	99	-	-	-	101	103	-	-	-	-	103	-	-
Salinas	"	100	-	-	-	-	101	103	-	-	-	101	-	-	-
Spreckels	"	100	100	-	-	99	99	106	101	-	-	102	104	-	-
"	"	100	101	-	-	-	100	102	-	-	-	-	-	-	-
Hollister	"	100	-	-	-	-	-	101	-	-	-	101	-	-	-
Gilroy	"	100	98	-	-	101	-	-	-	-	-	100	101	-	-
Watsonville	"	100	-	-	-	-	102	103	-	-	-	100	-	-	-
Central Valley															
Tracy	Holly	100	104	-	105	-	-	-	-	103	-	106	-	-	-
Gerber	"	100	106	-	108	-	-	-	-	-	-	-	-	-	-
So. San Joaquin, Fall	"	100	102	-	104	-	-	-	100	-	-	-	-	106	-
So. San Joaquin, Spr.	"	100	107	-	106	-	-	106	107	-	-	110	109	-	-

Sucrose percentage of bolting-resistant hybrids in 1960
California variety tests, expressed in percent of US 75
(Continued)

Location		US 75	US H2	US H3	US H4	US H5A	US H5B	US H6	887H5	9561H4	9561H5	F59-63H4	886H1	887H1	8539H2
Central Valley (Cont'd)															
Ryer Island	Holly	100	101	-	105	-	-	-	-	-	-	103	-	103	-
Staten Island	"	100	102	-	101	-	-	-	-	109	-	-	105	107	-
Hamilton City	"	100	104	-	105	-	-	-	-	-	-	-	-	104	-
Five Points	Spreckels	100	-	-	-	-	-	106	102	-	-	-	-	-	-
Dos Palos	"	100	103	-	-	-	-	-	-	-	-	-	-	-	-
Mendota	"	100	-	-	-	103	-	100	102	-	-	-	-	-	-
Imperial Valley															
Brawley - Early	USDA	100	98	102	102	100	99	100	-	102	101	101	106	106	107
" - Late	"	100	104	104	107	104	-	103	-	-	-	106	-	-	-
Imp. Val. - Early	Holly	100	99	-	102	-	-	99	-	-	-	99	105	104	-
" " "	"	100	103	-	107	-	-	104	-	-	-	106	108	104	-
" " "	"	100	104	-	109	-	-	104	-	-	-	106	108	105	-
" " "	"	100	101	-	108	-	-	97	-	-	-	106	109	102	-
" " - Late	"	100	100	-	107	-	-	100	-	-	-	102	106	100	-
" " "	"	100	99	-	102	-	-	98	-	-	-	99	104	101	-
" " "	"	100	100	-	104	-	-	99	-	-	-	101	104	100	-
" " "	"	100	105	-	109	-	-	100	-	-	-	106	106	108	-
" " - Inter.	"	100	98	-	101	-	-	-	104	102	104	-	-	-	-

VARIETY TEST, SALINAS, CALIFORNIA, 1960.

Location: Spence Field of the U. S. Agricultural Research Station.

Soil type: Sandy loam.

Previous crops: 1957, sugar beets; 1958 and 1959, barley cover crop.

Fertilizer used: 700 lbs. per acre 10:10:5, preplant.
400 lbs. per acre ammonium sulfate, sidedress, applied April 1, 1960.

Planting date: December 16, 1959.

Thinning date: February 24, 1960.

Harvest date: August 30-31, 1960.

Irrigations: At 7- to 10-day intervals with sprinkler system.

Diseases and insects: Infection with yellows viruses was moderate during the 1960 season. A moderately heavy infestation of leaf miner occurred in the test plot during June and July, causing some defoliation of plants. Sprayed with Systox and Dieldrin on June 8 for control of leaf miner.

Experimental design: Randomized block with seven replications. Varieties planted in two-row plots with rows spaced 28 inches apart. Plots 38 feet long.

Sugar analysis: From two 10-beet samples per plot by Spreckels Sugar Company, Spreckels, California.

VARIETY TEST, SALINAS, CALIFORNIA, 1960

(7 replications of each variety)

Planted December 16, 1959
Harvested August 29, 1960

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	Harvest Count Number
9952-2	(MS of NB1 x NB4) x D13	12,395	39.8	15.6	9.0	150
8539H2	7569H0 x 8539	12,080	37.9	16.0	12.9	153
863H5	7503H1 x 663	11,908	38.0	15.7	12.5	150
F59-63H2	US H6	11,814	37.3	15.8	5.8	163
863H7	US H5B	11,764	37.8	15.6	12.8	145
863H8	7569H0 x 663	10,950	34.6	15.9	4.3	141
9921H2	(MS of NB1 x NB4) x H3611	10,831	34.1	15.9	19.6	153
9921H3	7569H0 x H3611	10,535	32.5	16.2	21.0	142
9561H4	(MS of NB1 x NB3) x 9561	10,528	32.9	16.0	9.7	147
F59-86H3	US H5A	10,488	33.0	15.9	6.3	158
887H5	(MS of NB6 x NB5) x 787	10,482	33.5	15.7	1.4	154
368	US 75	9,155	29.6	15.5	4.9	149
General MEAN of all varieties		11,077	35.1	15.8	10.0	Beets per 100' row
S. E. of MEAN		278	0.86	0.14	1.34	
Significant Difference (19:1)		786	2.43	0.40	3.79	
S. E. of MEAN in % of MEAN		2.5	2.4	0.9	13.4	

(Odds 19:1 = 2 x $\sqrt{2}$ x Standard Error of MEAN)

VARIANCE TABLE

Variation due to	Degrees of freedom	Mean Squares: Gross Sugar	Tons Beets	Percent Sucrose	Percent Bolters
Between varieties	11	6,059,825	63.9	0.30	253.5
Between replications	6	3,360,223	45.8	1.34	20.1
Remainder (Error)	66	541,392	5.2	0.14	12.6
Total	83				
Calculated F Value		11.19**	12.38**	2.14*	20.12**

*Exceeds the 5% point of significance (F = 1.94)
**Exceeds the 1% point of significance(F = 2.54)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1959-60.

Location: Southwestern Irrigation Field Station.

Soil type: Holtville Silty Clay.

Previous crops: Barley, 1957, 1958 and 1959.

Fertilizer used: 90 lbs. per acre $P_2 O_5$, preplant.
80 lbs. per acre nitrogen, in the form of ammonium nitrate, preplant.
120 lbs. per acre nitrogen, in the form of ammonium nitrate, sidedress.

Planting date: September 9-10, 1959.

Thinning date: October 5-7, 1959.

Harvest dates: Early harvest, April 12-14, 1960.
Late harvest, June 3-4, 1960.

Irrigations: Early harvest, eight.
Late harvest, ten.

Diseases and insects: Curly top and yellows viruses were of minor importance in the 1959-60 test. One application of DDT spray was made September 24, 1959 for control of Desert Flea Beetle. One application of Endrin plus Metacide was made October 20, 1959 for control of Salt Marsh Caterpillar and Cabbage Looper.

Experimental design: Randomized block with eight replications and randomized block with four replications for the early harvested test. Randomized block with ten replications for the late harvested test. Varieties planted in two-row plots with rows spaced 30 inches apart. Plots 43 feet long.

Remarks: Test designed and results analyzed by the United States Agricultural Research Station, Salinas, California.

Plot under supervision of K. Beatty stationed at Southwestern Irrigation Field Station, Brawley, California.

VARIETY TEST, BRAWLEY, CALIFORNIA

(8 replicated plots of each variety)

Planted Sept. 9-10, 1959
Harvested April 12-14, 1960

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Harvest Count
		Pounds	Tons	Per Cent	Number
9921H1	(MS of NB1xNB3) x H3611	6,765	20.5	16.5	160
F59-63H3	US H5B	6,662	20.3	16.4	153
863H1	US H2	6,652	20.5	16.3	157
9921H2	(MS of NB1xNB4) x H3611	6,636	19.5	17.1	152
F59-63H2	(MS of NB1xNB5) x 663	6,320	19.1	16.6	158
F59-86H3	US H5 A	6,194	18.7	16.6	157
9561H4	(MS of NB1xNB3) x 9561	6,186	18.2	17.0	169
984H1	(MS of NB1xNB3) x 984	6,170	18.3	16.9	159
863H8	7569H0 x 663	6,034	18.0	16.7	156
9921H3	7569H0 x H3611	5,885	17.5	16.8	156
F58-86H7	US H3	5,754	17.1	16.9	152
459	US 56/2	5,741	16.6	17.3	158
F56-66H2	US H4	5,542	16.4	16.9	138
9561H5	F57-85H0 x 9561	5,539	16.6	16.7	162
886H1	7569H0 x 586	5,526	15.7	17.6	159
368	US 75	5,404	16.3	16.6	153
General MEAN of all varieties		6,063	18.1	16.8	Beets
S.E. of MEAN		157	0.47	0.23	per
Significant Difference (19:1)		441	1.32	0.65	100'
S.E. of MEAN % of MEAN		2.59	2.59	1.34	row

Odds 19:1 = 1.983 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degree of Freedom	MEAN SQUARES Gross Sugar	Tons Beets	Per Cent Sucrose
Between varieties	15	1,672,852	19.96	0.88
Between replicates	7	694,201	13.22	1.66
Remainder (Error)	105	197,776	1.76	0.41
Total	127			
Calculated F value		8.46**	11.34**	2.17*

* Exceeds the 5% point of significance (F=1.77)
** Exceeds the 1% point of significance (F=2.22)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1960

(10 replicated plots of each variety)

Planted Sept.9-10, 1959
Harvested June 3-4,1960

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
863H1	US H2	9,113	26.3	17.4	170
F59-63H2	US H6	8,937	25.9	17.3	174
F59-86H3	US H5A	8,399	24.2	17.4	171
F58-86H7	US H3	8,328	23.9	17.5	172
863H8	7569HO x 663	8,185	23.0	17.8	174
F56-66H2	US H4	7,793	21.7	17.9	164
459	US 56	7,453	20.6	18.1	167
368	US 75	6,436	19.2	16.8	158
General MEAN of all varieties		8,080	23.1	17.5	Beets per 100' row
S.E. of MEAN		216	0.72	0.27	
Significant Difference (19 : 1)		611	2.04	0.76	
S.E. of MEAN in % of MEAN		2.67	3.12	1.54	

(Odds 19 : 1 = $2\sqrt{2}$ x Standard Error of MEAN)

VARIANCE TABLE

Variation due to	Degrees of freedom	MEAN SQUARES Gross sugar	Tons beets	Percent sucrose
Between varieties	7	7,362,504	61.41	2.73
Between replications	9	1,230,388	12.44	1.61
Remainder (Error)	63	466,521	5.19	0.73
Total	79			
Calculated F value		15.78**	11.83**	3.74**

**Exceeds the 1% point of significance (F = 2.94)

VARIETY TEST, BRAWLEY, CALIFORNIA

(4 replicated plots of each variety)

Planted Sept. 9-10, 1959
Harvested April 12-14, 1960

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Harvest Count
		Pounds	Tons	Per Cent	Number
663H2	(MS of NB5xNB1) x 663	6,918	21.5	16.1	162
8539H2	7569H0 x 8539	6,896	20.8	16.6	160
863H5	7503H1 x 663	6,822	21.4	16.0	152
863H3	7507H1 x 663	6,574	20.7	15.9	169
863H9	7569H1 x 663	6,262	19.6	16.0	148
887H1	7569H0 x 787	5,793	17.7	16.4	149
368	US 75	5,414	17.6	15.5	148
9561H3	7569H0 x 9561	4,334	12.6	17.2	162
General MEAN of all varieties		6,126	19.0	16.2	Beets
S E of MEAN		211	0.76	0.28	per
Significant Difference (19:1)		621	2.24	0.83	100'
S E of MEAN in % of MEAN		3.45	4.02	1.75	row

Odds 19:1 $=2.080 \times \sqrt{2} \times$ Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	Tons Beets	Per Cent Sucrose
Between varieties	7	3,288,824	35.89	1.10
Between replicates	3	294,932	6.07	1.50
Remainder (Error)	21	178,497	2.33	0.32
Total	31			
Calculated F value		18.43**	15.40**	3.44*

* Exceeds the 5% point of significance (F=2.49)
** Exceeds the 1% point of significance (F=3.65)

VARIETY TEST, IMPERIAL VALLEY, CALIFORNIA, 1960

First planting - September 10, 1959

By Holly Sugar Corporation

Variety	Description	Gross sugar 1st.har.	Gross sugar 2nd.har.	Gross sugar 3rd.har.	Gross sugar 4th.har.	Tons per acre 1st.har.	Tons per acre 2nd.har.	Tons per acre 3rd.har.	Tons per acre 4th.har.	Sucrose 1st.har.	Sucrose 2nd.har.	Sucrose 3rd.har.	Sucrose 4th.har.
		Pounds	Pounds	Pounds	Pounds	Tons	Tons	Tons	Tons	Percent	Percent	Percent	Percent
Lot 9381	US H2	7,121	7,780	8,215	6,937	25.38	29.03	31.72	29.17	14.03	13.40	12.95	11.89
Lot 9374	US H4	6,797	7,373	8,323	6,838	23.59	26.37	30.64	26.90	14.41	13.98	13.58	12.71
Lot 9410	US H6	6,773	7,774	8,078	5,900	24.19	28.50	31.12	25.81	14.00	13.64	12.98	11.43
Lot 7252	US 75	6,462	6,602	7,093	5,738	22.82	25.26	28.35	24.29	14.16	13.07	12.51	11.81
887H1	7569H0 x 787	6,354	6,676	7,020	5,938	21.57	24.51	26.65	24.66	14.73	13.62	13.17	12.04
886H1	7569H0 x 586	6,036	6,584	6,665	6,119	20.35	23.41	24.72	23.85	14.83	14.06	13.48	12.83
F59-63H4	7569H0 x 663	5,849	6,489	7,458	6,163	20.94	23.53	28.04	24.73	13.97	13.79	13.30	12.46
General MEAN of all varieties in test		6,256	7,008	7,535	6,320	22.83	25.91	28.90	25.71	14.29	13.52	13.04	12.29
S. E. of MEAN		147A/	149A/	227A/	354A/	0.42	0.49	0.80	1.34	0.19	0.13	0.16	0.25
Significant Difference (19:1)		410	417	636	991	1.17	1.36	2.23	3.76	0.52	0.38	0.45	0.71
S. E. of MEAN in percent of MEAN		2.25	2.13	3.01	5.60	1.83	1.88	2.75	5.22	1.31	1.00	1.23	2.06

Variety	Description	Thin juice purity 1st.har.	Thin juice purity 2nd.har.	Thin juice purity 3rd.har.	Thin juice purity 4th.har.	Bolting 1st.har.	Bolting 2nd.har.	Bolting 3rd.har.	Bolting 4th.har.	Harvest count per 100' row 1st.har.	Harvest count per 100' row 2nd.har.	Harvest count per 100' row 3rd.har.	Harvest count per 100' row 4th.har.
		Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Number	Number	Number	Number
Lot 9381	US H2	91.67	91.30	91.29	84.92	0.4	1.6	1.7	0.5	154	142	138	124
Lot 9374	US H4	90.24	90.23	90.89	86.28	0.5	1.1	1.2	0.2	148	142	134	120
Lot 9410	US H6	89.99	90.58	90.65	84.12	0.3	0.2	0.7	0.5	145	142	136	124
Lot 7252	US 75	89.89	90.17	89.60	84.65	---	0.5	0.2	0.2	152	141	138	126
887H1	7569H0 x 787	90.39	89.64	90.07	84.28	---	0.4	---	---	151	148	141	124
886H1	7569H0 x 586	89.70	90.41	90.35	85.86	---	---	---	---	151	145	134	130
F59-63H4	7569H0 x 663	90.10	90.53	90.32	85.71	0.3	0.9	0.7	0.7	150	142	140	128
General MEAN of all varieties in test		90.35	90.59	90.59	85.44					151	143	137	126
S. E. of MEAN		0.28	0.36	0.34	0.56								
Significant Difference (19:1)		0.79	1.01	0.94	1.57								
S. E. of MEAN in percent of MEAN		0.31	0.40	0.37	0.66								

Harvest dates: April 27, 1960; May 24, 1960; June 27, 1960; July 25, 1960.

A/ By short cut formula.
Cooperator: Nelson Correll
Design: 4 x 4 Triple lattice - 9 replications.
Plot size: Two-rows spaced 30 inches apart and 53 feet long.
Two-rows x 50 feet harvested for first and second harvests.
Two-rows x 24 feet harvested for third and fourth harvests.

Beet Seed Breeding Department
Holly Sugar Corporation

The above results extracted from a test of 16 varieties.

VARIETY TEST, IMPERIAL VALLEY, CALIFORNIA, 1960

Second planting - October 10, 1959

By Holly Sugar Corporation

Variety	Description	Gross sugar 1st.har. Pounds	Gross sugar 2nd.har. Pounds	Gross sugar 3rd.har. Pounds	Gross sugar 4th.har. Pounds	Tons per acre 1st.har. Tons	Tons per acre 2nd.har. Tons	Tons per acre 3rd.har. Tons	Tons per acre 4th.har. Tons	Sucrose 1st.har. Percent	Sucrose 2nd.har. Percent	Sucrose 3rd.har. Percent	Sucrose 4th.har. Percent
Lot 9410	US H6	5,973	7,171	8,703	7,830	21.08	27.43	31.47	31.86	14.17	13.07	13.83	12.29
Lot 9381	US H2	5,835	7,262	8,754	8,364	20.75	27.57	31.17	32.29	14.06	13.17	14.04	12.95
Lot 9374	US H4	5,687	7,096	8,592	7,088	18.92	26.07	29.55	26.49	15.03	13.61	14.54	13.38
F59-63H4	7569HO x 663	5,354	6,883	8,698	8,235	18.63	25.93	30.89	31.46	14.37	13.27	14.08	13.09
887H1	7569HO x 787	5,325	6,673	7,892	8,167	18.79	24.75	28.23	30.73	14.17	13.48	13.98	13.29
Lot 7252	US 75	5,294	6,338	7,415	6,344	18.77	23.76	26.52	25.75	14.10	13.34	13.98	12.32
886H1	7569HO x 586	5,051	6,406	7,833	7,086	16.97	23.03	26.99	27.19	14.88	13.91	14.51	13.03
General MEAN of all varieties in test		5,456 A/	6,711 A/	8,190 A/	7,492 A/	19.20	25.25	29.01	29.08	14.22	13.29	14.11	12.37
S. E. of MEAN		139 A/	163 A/	231 A/	267 A/	0.43	0.52	0.62	0.93	0.17	0.17	0.26	0.20
Significant Difference (19:1)		389	457	643	747	1.20	1.46	1.73	2.60	0.49	0.48	0.73	0.57
S. E. of MEAN in percent of MEAN		2.55	2.43	2.83	3.56	2.24	2.06	2.13	3.20	1.22	1.29	1.35	1.57

Variety	Description	Thin juice purity 1st.har. Percent	Thin juice purity 2nd.har. Percent	Thin juice purity 3rd.har. Percent	Thin juice purity 4th.har. Percent	Bolting 1st.har. Percent	Bolting 2nd.har. Percent	Bolting 3rd.har. Percent	Bolting 4th.har. Percent	Harvest count per 100' row 1st.har. Number	Harvest count per 100' row 2nd.har. Number	Harvest count per 100' row 3rd.har. Number	Harvest count per 100' row 4th.har. Number
Lot 9410	US H6	89.94	91.52	91.85	87.49	---	0.1	0.1	0.1	212	209	204	200
Lot 9381	US H2	90.87	92.55	92.20	88.94	---	---	---	---	210	204	220	208
Lot 9374	US H4	90.55	91.53	92.53	90.03	---	0.1	0.2	0.2	209	197	203	190
F59-63H4	7569HO x 663	91.13	91.44	91.68	88.32	---	0.2	---	---	209	207	206	200
887H1	7569HO x 787	89.92	90.66	91.20	88.75	---	---	0.1	---	210	204	202	192
Lot 7252	US 75	90.29	90.70	91.57	88.68	---	0.2	---	0.1	214	204	205	190
886H1	7569HO x 536	89.95	91.40	92.00	87.76	---	---	---	---	210	203	206	192
General MEAN of all varieties in test		90.31	91.46	91.73	88.48					208	202	205	192
S. E. of MEAN		0.31	0.36	0.36	0.53								
Significant Difference (19:1)		0.88	1.00	1.02	1.48								
S. E. of MEAN in percent of MEAN		0.35	0.39	0.40	0.60								

Harvest dates: April 27, 1960; May 24, 1960; June 27, 1960; July 25, 1960.

A/By short cut formula.

Cooperator: Nelson Correll

Design: 4 x 4 Triple lattice with 9 replications.

Plot size: Two-rows spaced 30 inches apart and 53 feet long. Two-rows x 50' harvested for first and second harvests. Two-rows x 24' harvested for third and fourth harvests.

Results extracted from tests of 16 varieties.

Beet Seed Breeding Department
Holly Sugar Corporation

VARIETY TEST, IMPERIAL VALLEY, CALIFORNIA, 1960

Intermediate date of planting. By Holly Sugar Corporation.

Lot or Variety No.	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Bolting	Harvest Count
		Pounds	Tons	Percent	Percent	Number
Lot 9374	US H4	7,678	28.19	13.62	0.2	210
Lot 9381	US H2	7,363	28.13	13.09	0.2	206
9561H5	F57-85HO x 9561	7,223	26.00	13.89	0.2	206
887H5	(MS of NB6 x NB5) x 787	7,115	25.50	13.95	0.1	203
886H5	(MS of NB6 x NB5) x 586	7,059	24.80	14.23	0.2	209
9561H4	(MS of NB1 x NB3) x 9561	7,009	25.52	13.73	0.3	197
Lot 7317	US 75	6,580	24.51	13.42	-	202
Lot 819	US 56/2	6,410	22.89	14.00	0.1	206
F57-86	Bolt. res. sel. US 35	6,142	21.46	14.31	0.2	207
General MEAN of all varieties in test		7,036	25.65	13.72		204
S. E. of MEAN		180A/	0.55	0.19		Beets
Significant Difference (19 : 1)		502	1.53	0.54		per
S.E. of MEAN in % of MEAN		2.56	2.14	1.40		100' row

A/By short cut formula.

VARIANCE TABLE

Source of Variation	Degrees of Freedom	MEAN SQUARES Tons Beets	MEAN SQUARES Percent Sucrose
Variety	24	34.24	1.24
Replication	8	9.38	4.12
Error	192	2.73	0.33
Total	224		
Calculated F. value		12.56**	3.72**

**Exceeds the 1% point of significance (F = 1.88)

Cooperator : Nelson Correll.
Design : 5 x 5 Triple Lattice with 9 replications.
Plot size : Two-rows spaced 30 inches apart x 53 feet long.
Two-rows x 50 feet harvested.
Planted : October 10, 1959.
Harvested : May 20, 1960.

The above results extracted from a test of 25 varieties.

VARIETY TEST, TRACY, CALIFORNIA, 1960

By Holly Sugar Corporation

Lot or Variety No.	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Curly Top Percent	Harvest Count Number
Lot 9381	US H2	10,364	31.05	16.69	12.9	220
863H8	7569HO x 663	9,369	27.22	17.21	29.6	221
Lot 9354	US H4	9,259	27.49	16.84	11.6	219
Lot 813	US 75	8,908	27.76	16.05	17.9	216
F59-63H4	7569HO x F57-63	8,798	26.06	16.88	29.2	224
9561H4	(MS of NB1 x NB3) x 9561	7,997	24.22	16.51	8.8	209
F57-86	Bolt. Res. Sel. US 35	7,344	22.44	16.37	14.5	220
General MEAN of all varieties in test		8,917	27.15	16.44		211
S. E. of MEAN		241 A/	0.65	0.21		Beets per 100' row
Significant Difference (19:1)		670	1.81	0.58		
S. E. OF MEAN in % of MEAN		2.70	2.39	1.26		

A/ By short cut formula.

VARIANCE TABLE

Source of Variation	Degrees of Freedom	MEAN SQUARES Tons Beets	MEAN SQUARES Percent Sucrose
Replication	8	59.55	0.95
Variety	41	75.63	3.39
Error	328	3.79	0.39
Total	377		
Calculated F value		19.97**	8.78**

** Exceeds the 1% point of significance (F = 1.64)

Cooperator: John Paulson
Design: 6 x 7 Rectangular Lattice with 9 replications.
Plot size: Two-rows spaced 30 inches apart and 53 feet long.
Two-rows x 50 feet harvested.
Planted: April 6, 1960.
Harvested: November 4, 1960.

The above results extracted from a test of 42 varieties.

VARIETY TEST, SOUTH SAN JOAQUIN, CALIFORNIA, 1960

Fall planted. By Holly Sugar Corporation

Lot or Variety No.	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Curly Top	Bolting	Harvest Count
		Pounds	Tons	Percent	Percent	Percent	Number
Lot 9381	US H2	7,596	30.60	12.41	40.00	0.8	118
Lot 9374	US H4	6,941	27.46	12.64	35.18	0.4	123
887H1	7569HO x 787	6,776	26.24	12.91	45.30	0.1	126
887H5	(MS of NB6 x NB5) x 787	6,421	26.34	12.19	31.90	-	134
886H5	(MS of NB6 x NB5) x 586	5,413	22.90	11.82	37.25	-	132
Lot 7317	US 75	5,235	21.44	12.21	36.59	0.3	125
General MEAN of all varietiesin test		6,275	25.42	12.30			128
S. E. of MEAN		402A/	1.54	0.25			Beets
Significant Difference (19:1)		1,129	4.34	0.70			per
S. E. of MEAN in % of MEAN		6.41	6.07	2.02			100' row

A/ By short cut formula.

VARIANCE TABLE

Source of Variation	Degrees of Freedom	MEAN SQUARES Tons Beets	MEAN SQUARES Percent Sucrose
Variety	11	96.85	1.52
Replication	8	375.42	3.12
Error	88	21.45	0.56
Total	107		
Calculated F. value		4.51**	2.74**

**Exceeds the 1% point of significance (F = 2.48)

Cooperator : Ed. Irwin
Design : 3 x 4 Triple Rectangular Lattice - 9 reps.
Plot size : Two-rows spaced 30 inches apart and 53 feet long.
Two-rows x 50 feet harvested.
Planted : October 16, 1959.
Harvested : August 11, 1960.

The above results extracted from a test of 12 varieties.

VARIETY TEST, SOUTH SAN JOAQUIN, CALIFORNIA, 1960

Spring planted. By Holly Sugar Corporation

Lot or Variety No.	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
Lot 9381	US H2	6,264	20.61	15.20	178
663H2	US H6	5,657	18.81	15.04	165
887H5	(MS of NB6 x NB5)x 787	5,611	18.49	15.17	160
863H8	7569HO x 663	5,508	17.61	15.64	186
886H1	7569HO x 586	5,448	17.69	15.40	183
Lot 9354	US H4	5,259	17.48	15.04	171
Lot 813	US 75	4,880	17.23	14.16	173
F57-86	Bolt. res. sel. US 35	4,536	14.79	15.33	172
General MEAN of all varieties in test		5,447	18.09	15.05	174
S. E. of MEAN		345 A/	1.10	0.28	Beets
Significant Difference (19:1)		962	3.06	0.77	per
S. E. of MEAN in % of MEAN		6.33	6.06	1.84	100' row

A/ By short cut formula

VARIANCE TABLE

Source of Variation	Degrees of Freedom	MEAN SQUARES Tons Beets	MEAN SQUARES Percent Sucrose
Variety	29	26.34	1.50
Replication	8	154.39	11.74
Error	232	10.82	0.69
Total	269		
Calculated F. value		2.43**	2.17**

**Exceeds 1% point of significance (F = 1.79)

Cooperator : E. V. Bowles
Design : 5 x 6 Triple Rectangular Lattice - 9 reps.
Plot size : Two-rows spaced 30 inches apart x 53 feet long.
Two-rows x 50 feet harvested.
Planted : February 12, 1960 (in moisture).
Hargested : August 18, 1960.

The above results extracted from a test of 30 varieties.

VARIETY TEST, STATEN ISLAND, CALIFORNIA, 1960

By Holly Sugar Corporation

Lot of Variety No.	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
9561H4	(MS of NB1 x NB3) x 9561	7,465	27.37	13.64	182
Lot 9381	US H2	7,413	29.28	12.66	157
887H1	7569H0 x 787	7,241	27.10	13.36	165
Lot 9354	US H4	6,938	27.60	12.57	166
Lot 813	US 75	6,464	25.94	12.46	176
886H1	7569H0 x 586	6,219	23.70	13.12	181
General MEAN of all varieties in test		7,004	27.15	12.90	Beets
S. E. of MEAN		399A/	1.39	0.32	per
Significant Difference (19:1)		1,114	3.88	N.S.	100'
S. E. of MEAN in % of MEAN		5.70	5.12	2.51	row

A/ By short cut formula.

VARIANCE TABLE

Source of Variation	Degrees of Freedom	MEAN SQUARES Tons Beets	MEAN SQUARES Percent Sucrose
Replication	8	892.35	19.42
Varieties	24	72.42	1.34
Error	192	17.41	0.94
Total	224		
Calculated F value		4.16**	N.S.

** Exceeds the 1% point of significance (F = 1.88)

Cooperator: M & T, Inc.
Design: 5 x 5 Triple Lattice with 9 replications.
Plot size: Two-rows spaced 20 inches apart and 53 feet long.
Two-rows x 50 feet harvested.
Planted: March 23, 1960, (in moisture).
Harvested: November 17-18, 1960.

The above results extracted from a test of 25 varieties.

VARIETY TEST, RYER ISLAND, CALIFORNIA, 1960

By Holly Sugar Corporation

Lot or Variety No.	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
Lot 9381	US H2	6,998	23.77	14.72	186
F59-63H4	7569HO x F57-63	6,507	21.70	14.99	193
Lot 9354	US H4	6,437	21.15	15.22	197
887H1	7569HO x 787	6,400	21.48	14.90	203
Lot 813	US 75	5,978	20.60	14.51	193
General MEAN of all varieties in test		6,013	20.47	14.73	190
S. E. of MEAN		237 A/	0.77	0.18	Beets
Significant Difference (19:1)		661	2.14	0.49	per
S. E. of MEAN in % of MEAN		3.94	3.76	1.20	100' row

A/ By short cut formula

VARIANCE TABLE

Source of Variation	Degrees of Freedom	MEAN SQUARES Tons Beets	MEAN SQUARES Percent Sucrose
Variety	29	104.50	1.81
Replication	8	222.93	14.38
Error	232	5.32	0.28
Total	269		
Calculated F. value		19.63**	6.41**

**Exceeds 1% point of significance (F = 1.79)

Cooperator : Jongeneel and Hechtman.
Design: 5 x 6 Triple Rectangular Lattice - 9 reps.
Plot size : Two-rows spaced 28 inches apart x 53 feet long.
Two-rows x 50 feet harvested.
Planted : February 24, 1960 (in moisture).
Harvested : August 30, 1960.

The above results extracted from a test of 30 varieties.

VARIETY TEST, HAMILTON CITY, CALIFORNIA, 1960

By Holly Sugar Corporation

Lot or Variety No.	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Harvest Count
		Pounds	Tons	Percent	Number
9921H1	(MS of NB1 x NB3) x H3611	6,678	21.57	15.48	175
9921H2	(MS of NB1 x NB4) x H3611	6,146	21.04	14.61	177
9921H3	7569HO x H3611	5,837	18.96	15.39	210
Lot 9354	US H4	5,739	18.54	15.48	210
Lot 9381	US H2	5,719	18.62	15.36	200
Lot 813	US 75	5,470	18.59	14.71	213
887H1	7569HO x 787	5,219	17.14	15.23	204
General MEAN of all varieties in test		5,607	18.71	14.97	205
S. E. of MEAN		292 A/	0.88	0.34	Beets
Significant Difference (19:1)		815	2.45	0.93	per
S. E. of MEAN in % of MEAN		5.21	4.69	2.24	100' row

A/ By short cut formula.

VARIANCE TABLE

Source of Variation	Degrees of Freedom	MEAN SQUARES Tons Beets	MEAN SQUARES Percent Sucrose
Variety	24	2.41	1.96
Replication	8	17.18	9.26
Error	192	0.69	1.01
Total	224		
Calculated F. value		3.48**	1.94**

**Exceeds 1% point of significance (F= 1.88)

Cooperator : George Stutz.
Design : 5 x 5 Triple Lattice - 9 reps.
Plot size : Two-rows 30 inches apart x 53 feet long.
Two-rows x 50 feet harvested.
Planted : March 2, 1960
Harvested : September 7-8, 1960.

The above results extracted from a test of 25 varieties.

VARIETY TEST, GERBER, CALIFORNIA, 1960

By Holly Sugar Corporation

Lot No.	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Curly Top[1] Index	L.S.R.[1] Index	Harvest Count Number
Lot 9381	US H2	5,784	23.57	12.27	2.4	2.2	152
Lot 813	US 75	5,754	24.76	11.62	1.9	2.3	160
Lot 9354	US H4	5,598	22.34	12.53	2.2	2.6	150
General MEAN of all varieties in test		5,644	22.86	12.34			156
S. E. of MEAN		215[2]	0.82	0.16			Beets per 100' row
Significant Difference (19:1)		601	2.29	0.45			
S. E. of MEAN in % of MEAN		3.80	3.58	1.29			

[1] Rated from 1 to 10, 1 = least amount.

[2] By short cut formula.

VARIANCE TABLE

Source of Variation	Degrees of Freedom	MEAN SQUARES Tons Beets	MEAN SQUARES Percent Sucrose
Replication	8	39.32	0.78
Variety	15	55.01	1.54
Error	120	6.02	0.23
Total	143		
Calculated F value		9.13**	6.78**

** Exceeds the 1% point of significance (F = 2.23)

Cooperator: Dean Glatz
Design: 4 x 4 Triple Lattice with 9 replications.
Plot size: Two-rows spaced 30 inches apart and 48 feet long.
Two-rows x 45 feet harvested.
Planted: March 30, 1960.
Harvested: October 13-14, 1960.

The above results were extracted from a test of 16 varieties.

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, DISTRICT 1, 1960

Test Areas:	Spreckels Ranch				Spreckels Ranch				Spreckels Ranch				Spreckels Ranch			
VARIETY	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'
F59-63H2	2.744	20.61	13.3	112	2.935	23.12	12.7	101								
C9921H3	2.649	20.29	13.1	104					2.305	19.04	12.1	106				
C9921H2	2.558	19.58	13.1	100					2.469	20.98	11.8	98				
C9921H1	2.505	19.12	13.1	86					2.218	19.46	11.4	89				
F59-63H3					2.984	24.98	11.9	111								
863H8					2.943	24.35	12.1	109								
F59-63H4					2.830	23.29	12.2	103								
F59-86H3					2.750	23.01	11.9	110								
787H2					2.675	22.09	12.1	106								
F59-63H1					2.669	22.23	12.0	106								
886H1					2.666	21.43	12.5	106								
887H5					2.609	21.51	12.1	101								
886H5					2.550	21.03	12.1	104								
US 75					2.435	20.38	12.0	104								
C9561H5													2.553	21.74	11.7	99
US 56/2													2.168	17.32	12.5	96
Planting Date:	January 7, 1960				November 30, 1959				November 30, 1959				November 30, 1959			
Harvest Date	September 1, 1960				August 22, 1960				August 25, 1960				August 24, 1960			
General Mean	2.363	18.58	12.7	99	2.702	22.33	12.1	105	2.368	20.26	11.7	101	2.236	19.75	11.3	102
LSD @ P - .05	.228	1.371	NS		0.356	2.777	NS		NS	NS	NS		0.270	2.462	5.415	
LSD @ P - .01	.302	2.230	NS		0.472	3.684	NS		NS	NS	NS		0.359	3.272	7.198	
S E of Mean	.081	0.597	0.138		0.126	0.987	0.205		0.034	0.887	0.219		0.119	0.871	0.192	
S E % of Mean	3.428	3.213	1.09		4.66	4.42	1.70		1.453	4.378	1.873		5.322	4.410	1.699	
No. of Varieties in Test	twelve				twelve				eight				ten			

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, DISTRICT I, 1960

Test Areas:	Don Davies (Salinas)				Pete Fanucchi (Watsonville)				Spreckels Ranch				Joseph Gubser (Gilroy)			
VARIETY	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'
F59-63H3	6.371	40.32	15.8	143	4.309	31.53	13.7	105								
F59-63H2	6.333	39.11	16.2	140	4.003	28.91	13.8	96								
F59-63H4	5.729	36.21	15.8	134	3.853	28.74	13.4	98					5.985	39.31	15.3	141
US 75	5.615	35.71	15.7	139	3.636	27.28	13.4	106	1.728	14.23	12.1	110	5.725	37.46	15.3	146
C9921H1									2.190	17.48	12.5	95				
C9921H2									2.135	16.96	12.6	100				
SL6933									2.105	17.18	12.2	105				
F59-63H1													5.866	39.06	15.0	135
F59-86H3													5.615	36.44	15.4	146
886H1													4.804	31.32	15.4	138
Planting Date:	March 3, 1960				March 18, 1960				January 28, 1960				December 12, 1959			
Harvest Date:	October 5, 1960				September 21, 1960				August 26, 1960				August 19, 1960			
General Mean:	6.032	38.503	15.7	139	4.162	31.25	13.3	98	2.144	17.89	12.0	104	5.688	37.65	15.1	137
LSD @ P - .05	.515	3.231	.561		.484	3.131	.559		.360	2.327	1.11		.663	4.370	0.42	
LSD @ P - .01	.685	4.295	.746		.643	4.162	.744		.478	3.087	1.474		.882	5.809	0.56	
S E of Mean:	0.182	1.518	0.206		0.171	1.109	.198		0.128	0.826	0.396		0.235	1.546	0.148	
S E % of Mean:	3.02	3.94	1.31		4.11	3.55	1.49		5.970	4.617	3.300		4.137	4.106	0.98	
No. of Varieties in Test:	ten				ten				fifteen				ten			

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, DISTRICT 1, 1960

Test Areas:	James Fanoe (Alisal)				Geo. Stevens (Gilroy-Holl.)				Spreckels Ranch			
VARIETY	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	Tons Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'
F59-63H2	6.594	40.40	16.3	159	3.686	29.73	12.4	115	2.570	20.00	12.9	116
F59-63H3	6.491	40.96	15.9	166					2.490	19.60	12.7	112
F59-63H1	6.258	39.90	15.7	159					2.383	18.59	12.8	110
US 75	5.723	36.30	15.8	158	3.016	24.41	12.3	117	2.050	16.19	12.7	111
886H1	5.678	35.02	16.2	157								
F59-63H4					3.324	26.78	12.4	120				
US 56/2									2.030	15.45	13.2	98
Planting Date:	November 27, 1959				March 28, 1960				January 7, 1960			
Harvest Date:	September 9, 1960				October 6, 1960				September 1, 1960			
General Mean	6.109	38.69	15.8	158	3.493	27.95	12.5	119	2.300	18,27	12.6	110
LSD @ P - .05	0.348	2.17	0.52		.433	3.297	NS		.206	NS	.435	
LSD @ P - .01	0.464	2.90	0.70		.577	4.394	NS		.274	NS	.578	
S E of Mean	.122	.764	.184		0.153	1.162	0.186		0.073	0.532	0.154	
S E % of Mean	2.00	2.92	1.16		4.380	4.158	1.49		3.174	2.91	1.223	
No. of Varieties in Test		eight				nine				ten		

DATA ON U.S.D.A. VARIETIES TESTED BY SPRECKELS SUGAR COMPANY, 1960

Test Areas:	FIVE POINTS				YUBA CITY				DOS PALOS				MENDOTA			
V A R I E T Y	TONS Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	TONS Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	TONS Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'	TONS Sug/Ac.	Beets T/Ac.	% Sugar	Beets 100'
F-59-63H-2	1.84	11.62	15.79	133												
887H-5	1.60	10.65	15.12	125												
US 75	1.22	8.26	14.86	120					1.98	13.14	15.15	182	1.57	12.41	12.63	132
US 56/2					2.113	13.76	15.6	103								
US 400					2.415	16.05	15.0	110								
984H-1					1.613	8.16	15.3	75								
863H-1									2.59	16.45	15.68	213				
787H-2													2.00	15.63	12.83	130
F-59-63H-2													1.92	15.13	12.67	140
F-59-86H-3													1.70	13.23	12.97	140
Planting Date:	October 22, 1959				April 7, 1960				December 10, 1959				December 10, 1959			
Harvest Date:	July 19, 1960				September 9, 1960				September 27, 1960				September 1, 1960			
General Mean:	1.42	9.40	15.16		2.04	13.5	15.14		2.18	13.81	15.74		1.77	13.44	13.17	
LSD @ P - .05	0.213	1.34	0.50		NS	4.17	.62		0.237	2.21	0.56		0.43	3.07	0.63	
LSD @ P - .01	0.284	1.79	0.67		--	--	-----		0.316	2.94	0.74		0.56	4.08	0.84	
S E of Mean																
S E % of Mean																
No. of Varieties in test.	eight				sixteen				eight				sixteen			

VARIETY TEST, OXNARD, CALIFORNIA, 1960

By Union Sugar Division

Grower and location : Milton Borchard, Oxnard, California.

Soil type : Sandy loam.

Previous crops : Beans, 1956; carrots, 1957; vegetables, 1958; spinach, 1959.

Fertilizer used : 150 units of nitrogen per acre, in the form of ammonium nitrate, was incorporated into the bed at time of listing. Date of application was March 15, 1960.

Planting date : March 18, 1960.

Thinning date : Week of April 18, 1960.

Harvest date : October 21, 1960.

Irrigations : Three.

Diseases and insects : Diseases and insects were of no importance in this test.

Fumigation for nematode : Telone, at the rate of 10 gallons per acre, was incorporated into the bed at time of listing. Date of application was March 15, 1960.

Experimental design : Randomized block with eight replications. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis : From two ten-beet samples per plot by Union Sugar, Betteravia, California.

Remarks : Seed was furnished, test designed and results analyzed by United States Agricultural Research Station, Salinas, California.

VARIETY TEST, OXNARD, CALIFORNIA, 1960

(8 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
F59-63H3	US H5B	8,396	36.9	11.4	123
F59-63H2	US H6	8,189	37.7	10.9	121
863H5	7503H1 x 663	8,131	39.0	10.4	117
F59-86H3	US H5A	7,850	32.5	12.1	120
887H5	(MS of NB6 x NB5) x 787	7,663	33.9	11.3	117
9921H3	7569H0 x H3611	7,662	33.7	11.4	116
9921H2	(MS of NB1 x NB4) x H3611	7,520	32.7	11.5	113
368	US 75	7,321	33.1	11.1	116
F59-63H4	8569H1 x 663	7,031	32.9	10.7	118
9561H5	F57-85H0 x 9561	6,823	31.4	10.9	118
General MEAN of all varieties		7,659	34.4	11.2	Beets per 100' row
S. E. of MEAN		343	1.0	0.34	
Significant Difference (19:1)		971	2.8	N.S.	
S. E. of MEAN in % of MEAN		4.5	2.9	3.1	

(Odds 19:1 = 2 x $\sqrt{2}$ x Standard Error of MEAN)

VARIANCE TABLE

Variation due to	Degrees of freedom	MEAN SQUARES Gross Sugar	MEAN SQUARES Tons Beets	MEAN SQUARES Percent Sucrose
Between varieties	9	2,053,844	52.39	1.89
Between replications	7	3,630,539	56.16	10.06
Remainder (Error)	63	942,421	7.98	0.94
Total	79			
Calculated F Value		2.18*	6.57**	N.S.

*Exceeds the 5% point of significance (F = 2.03)
**Exceeds the 5% point of significance(F = 2.71)

VARIETY TEST, BETTERAVIA, CALIFORNIA, 1960

By Union Sugar Division

Grower and location : Pezzoni and Silva, Pezzoni Ranch, Guadalupe, California.

Soil type : Yolo sandy loam.

Previous crops : Beets, 1956; beans, 1957, 1958 and 1959.

Fertilizer used : 1300 lbs. per acre ammonium sulfate, preplant and sidedress.

Planting date : January 8, 1960.

Thinning date : Late February, 1960.

Harvest date : October 10, 1960.

Irrigations : Five.

Diseases and insects : Diseases, except for a light rust infection, were not a factor in the test plot during the 1960 season. Nematode infestation was fairly uniform throughout the test plot but caused only light damage to the beets.

Experimental design : Randomized block with eight replications. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis : From two ten-beet samples by Union Sugar, Betteravia, California.

Remarks : Seed was furnished, test designed and results analized by United States Agricultural Research Station, Salinas, California.

VARIETY TEST, BETTERAVIA, CALIFORNIA, 1960

(8 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	Harvest Count Number
F59-63H3	US H5B	11,234	42.4	13.2	1.9	138
9921H2	(MS of NB1 x NB4)x H3611	11,036	41.0	13.5	5.5	127
F59-63H2	US H6	11,021	41.3	13.4	3.4	132
F59-86H3	US H5A	10,230	36.8	13.9	2.4	134
863H5	7503H1 x 663	10,066	43.8	11.5	10.8	126
F59-63H4	8569H1 x 663	10,011	39.2	12.8	3.7	145
9921H3	7569H0 x H3611	9,944	37.8	13.2	6.7	133
9561H5	F57-85H0 x 9561	9,627	38.5	12.6	1.5	133
887H5	(MS of NB6 x NB5) x 787	9,159	37.8	12.1	0.6	126
368	US 75	9,025	34.9	13.0	1.1	124
General MEAN of all varieties		10,135	39.3	12.9	3.7	Beets per 100' row
S. E. of MEAN		327	1.00	0.21	0.57	
Significant Difference (19:1)		924	2.83	0.60	1.60	
S. E. of MEAN in % of MEAN		3.2	2.5	1.6	15.2	

(Odds 19:1 = 2 x $\sqrt{2}$ x Standard Error of MEAN)

VARIANCE TABLE

Variation due to	Degrees of freedom	MEAN SQUARES Gross sugar	Tons Beets	Percent Sucrose	Percent Bolting
Between varieties	9	4,721,506	60.63	4.02	79.44
Between replications	7	5,323,678	29.72	9.47	1.83
Remainder (Error)	63	853,766	8.02	0.36	2.57
Total	79				
Calculated F value		5.53**	7.56**	11.17**	30.91**

**Exceeds the 1% point of significance (F = 2.71)

VARIETY TEST, SALINAS, CALIFORNIA, 1960

By Union Sugar Division.

Grower and location : William H. Ferrasci, Salinas, California.

Soil type : Chualar sandy loam.

Previous crops : Beets, 1956; lettuce, 1957; beans and cover crop, 1958; beans, 1959.

Fertilizer used : 400 lbs. per acre 16:20:0, preplant. 350 lbs. ammonium nitrate, sidedress.

Planting date : March 2, 1960.

Thinning date : April 16, 1960.

Harvest date : October 28, 1960.

Irrigations : Six.

Diseases and insects : Post-emergence damping-off and cutworm damage resulted in spotty stand of beets in the test plot. Moderate infection with the yellows viruses occurred during the 1960 season.

Experimental design : Randomized block with eight replications and randomized block with four replications. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long, but only a 12-foot section of each plot harvested because of spotty stand.

Sugar analysis : From two ten-beet samples per plot by Union Sugar, Betteravia, California.

Remarks : The average yield of the acreage under the Ferrasci Union Sugar contract, in which the test plot was located, was 26.93 tons per acre with a sucrose content of 16.10 percent.

VARIETY TEST, SALINAS, CALIFORNIA, 1960

(8 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
9921H2	(MS of NB1 x NB4) x H3611	10,017	31.3	16.0	158
9921H3	7569HO x H3611	9,701	29.1	16.6	150
F59-86H3	US H5A	9,346	29.5	15.9	146
F59-63H2	US H6	9,179	28.8	15.9	154
887H5	(MS of NB6 x NB5) x 787	8,950	28.1	15.9	121
863H5	7503H1 x 663	8,810	28.7	15.4	117
787H1	(MS of NB1 x NB4) x 787	8,778	28.1	15.6	146
F59-63H3	US H5B	8,689	27.0	16.1	163
9561H5	F57-85HO x 9561	8,686	27.2	16.0	150
F59-63H4	8569H1 x 663	8,665	27.2	15.9	142
E-67	T.A.S. Co., mm hybrid	8,627	27.3	15.8	146
368	US 75	8,018	25.6	15.6	142
General MEAN of all varieties		8,955	28.1	15.9	Beets per 100' row
S. E. of MEAN		351	2.80	0.20	
Significant Difference (19 : 1)		988	0.89	0.57	
S. E. of MEAN in % of MEAN		3.9	3.5	1.3	

(Odds 19 : 1 = 1.991 x $\sqrt{2}$ x Standard Error of MEAN)

VARIANCE TABLE

Variation due to	Degrees of freedom	MEAN SQUARES Gross sugar	Tons beets	Percent sucrose
Between varieties	11	2,293,545	16.93	0.77
Between replications	7	2,896,693	17.63	1.59
Remainder (Error)	77	986,644	7.93	0.33
Total	95			
Calculated F value		2.33*	2.13*	2.32*

* Exceeds the 5% point of significance (F = 1.92)

VARIETY TEST, SALINAS, CALIFORNIA, 1960

(4 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Harvest Count
		Pounds	Tons	Percent	Number
8539H1	7507H1 x 8539	9,848	32.8	15.0	138
8539H2	7569H0 x 8539	9,826	31.6	15.5	150
L7349	Polybeta	9,767	30.0	16.3	133
F59-63H1	US H2	9,353	29.4	15.9	167
9921H1	(MS of NB1 x NB3) x H3611	9,120	29.5	15.4	142
09	Klein E	8,885	29.2	15.3	154
F56-66H2	US H4	8,569	26.9	15.9	125
368	US 75	8,286	26.6	15.6	138
F58-86H7	US H3	8,244	27.0	15.2	129
9948	Swedish Diploid	7,631	23.9	16.0	167
9561H4	(MS of NB1 x NB3) x 9561	7,444	24.1	15.5	150
9949	Swedish Diploid	7,403	22.6	16.4	175
General MEAN of all varieties		8,698	27,8	15.7	Beets per 100' row
S.E. of MEAN		419	0.78	0.29	
Significant Difference (19 : 1)		1,205	2.24	0.83	
S.E. of MEAN in % of MEAN		4.8	2.8	1.8	

(Odds 19 : 1 = 2.03 x$\sqrt{2}$ x Standard Error of MEAN)

VARIANCE TABLE

Variation due to	Degrees of freedom	MEAN SQUARES Gross sugar	Tons beets	Percent Sucrose
Between varieties	11	3,330,683	49.53	0.75
Between replications	3	2,027,457	16.74	0.74
Remainder (Error)	33	702,483	2.42	0.33
Total	47			
Calculated F value		4.74**	20.47**	2.27*

*Exceeds 5% point of significance (F = 2.09)
**Exceeds 1% point of significance (F = 2.84)

VARIETY TEST, KING CITY, CALIFORNIA, 1960

By Union Sugar Division

Grower and location : A.S. Duarte, King City, California

Soil type : Salinas clay.

Previous crops : Sugar beets, 1956; tomatoes, 1957; beans, 1958; lettuce, 1959.

Fertilizer used : 300 lbs. per acre 16:10:0, preplant.
500 lbs. per acre ammonium sulfate, sidedress.

Planting date : February 26, 1960.

Thinning date : April 4, 1960.

Harvest date : October 25, 1960.

Irrigations: Five.

Diseases and insects : Light infestations of leaf miner and nematode occurred in the plot area. Diseases were not a problem during the 1960 season.

Experimental design : Randomized block with eight replications and randomized block with four replications. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis : From two ten-beet samples per plot by Union Sugar, Betteravia, California.

Remarks : Seed was furnished, test designed and results analyzed by the United States Agricultural Research Station, Salinas, California.

VARIETY TEST, KING CITY, CALIFORNIA, 1960

(8 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
F59-63H3	US H5B	11,208	37.0	15.2	182
787H1	(MS of NB1 x NB4) x 787	11,074	36.6	15.1	174
F59-63H1	US H2	11,021	35.6	15.5	176
F59-86H3	US H5A	10,627	33.9	15.7	184
F59-63H2	US H6	10,606	34.6	15.3	178
9921H1	(MS of NB1 x NB3) x H3611	10,406	34.2	15.2	155
F59-63H4	8569H1 x 663	10,368	34.0	15.3	182
E-67	TASCO mm Hybrid	10,202	31.6	16.2	168
9561H5	F57-85H0 x 9561	10,156	33.1	15.4	172
9921H3	7569H0 x H3611	9,970	33.0	15.1	162
368	US 75	9,046	31.5	14.3	163
9561H4	(MS of NB1 x NB3) x 9561	8,590	29.7	14.5	166
General MEAN of all varieties		10,273	33.7	15.2	Beets per 100' row
S. E. of MEAN		244	0.70	0.19	
Significant Difference (19:1)		686	1.97	0.54	
S. E. of MEAN in % of MEAN		2.4	2.1	1.3	

(Odds 19:1 = 1.99 x $\sqrt{2}$ x Standard Error of MEAN)

VARIANCE TABLE

Variation due to	Degrees of freedom	MEAN SQUARES Gross sugar	Tons Beets	Percent Sucrose
Between varieties	11	4,935,844	37.16	1.84
Between replications	7	2,521,820	28.68	1.12
Remainder (Error)	77	476,158	3.94	0.30
Total	95			
Calculated F value		10.37**	9.43**	6.13**

**Exceeds the 1% point of significance (F = 1.91)

VARIETY TEST, KING CITY, CALIFORNIA, 1960

(4 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
9953-6	7569HO x E10	12,198	40.0	15.2	154
8539H2	7569HO x 8539	11,964	39.4	15.2	168
9953-2	7569HO x D13	11,766	37.6	15.6	144
9952-2	(MS of NB1 x NB4) x D13	11,763	40.1	14.7	153
9952-4	(MS of NB1 x NB4) x D38	11,646	39.8	14.7	153
863H5	7503H1 x 663	11,327	38.1	14.9	147
F58-86H7	US H3	10,831	33.1	16.3	172
887H5	(MS of NB6 x NB5) x 787	10,662	35.4	15.1	149
9921H2	(MS of NB1 x NB4) x H3611	10,621	35.6	14.9	166
F56-66H2	US H4	10,592	32.7	16.2	158
1-300	Klein E	10,350	33.2	15.6	152
368	US 75	10,030	33.6	15.0	163
General MEAN of all varieties		11,146	36.6	15.3	Beets
S. E. of MEAN		329	0.94	0.21	per
Significant Difference (19:1)		944	2.69	0.61	100'
S. E. of MEAN in % of MEAN		2.9	2.6	1.4	row

(Odds 19:1 = 2.03 x $\sqrt{2}$ x Standard Error of MEAN)

VARIANCE TABLE

Variation due to	Degrees of freedom	MEAN SQUARES Gross sugar	Tons Beets	Percent Sucrose
Between varieties	11	2,043,399	34.71	1.26
Between replications	3	667,942	5.17	0.44
Remainder (Error)	33	432,369	3.52	0.18
Total	47			
Calculated F value		4.73**	9.86**	7.00**

**Exceeds the 1% point of significance (F = 2.84)

VARIETY TEST, SAN ARDO, CALIFORNIA, 1960

By Union Sugar Division

Growers and location : Salaberry and Giudici, San Ardo, California.

Soil type : Docos clay loam.

Previous crops : Beans, 1956 and 1957; onions, 1958; beans, 1959.

Fertilizer used : 400 lbs. per acre 16:20:0, sidedress 300 lbs. per acre ammonium sulfate, sidedress.

Planting date : February 27, 1960.

Thinning date : April 20, 1960.

Harvest date : October 18, 1960.

Irrigations : Seven.

Diseases and insects : Infections with the yellows viruses was generally low during the 1960 season. Insects were not a problem in the test plot. Nematode damage was light in the test.

Experimental design : Randomized block with eight replications and randomized block with four replications. Varieties planted on double-row beds with 40-inch centers. Plots 60 feet long.

Sugar analysis : From two ten-beet samples by Union Sugar, Betteravia, California.

Remarks : Seed was furnished, test designed and results analyzed by United States Agricultural Research Station, Salinas, California.

VARIETY TEST, SAN ARDO, CALIFORNIA, 1960

(8 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
F59-63H2	US H6	12,307	34.6	17.8	189
787H1	(MS of NB1 x NB4) x 787	12,104	34.0	17.8	204
F59-63H3	US H5B	12,081	33.4	18.1	200
F59-63H4	8569H1 x 663	11,871	32.2	18.4	195
F59-63H1	US H2	11,859	33.5	17.7	202
E-67	T.A.S. Co. mm hybrid	11,699	30.7	19.0	178
9921H1	(MS of NB1 x NB3) x H3611	11,367	31.6	18.0	176
9561H5	F57-85HO x 9561	11,313	31.0	18.2	195
9921H3	7569HO x H3611	11,182	31.2	17.9	188
F59-86H3	US H5A	11,123	30.6	18.2	194
368	US 75	11,058	30.7	18.0	197
9561H4	(MS of NB1 x NB3) x 9561	9,910	28.1	17.6	191
General MEAN of all varieties		11,490	31.8	18.1	Beets
S. E. of MEAN		228	0.51	0.22	per
Significant Difference (19:1)		642	1.45	0.61	100'
S. E. of MEAN in % of MEAN		2.0	1.6	1.2	row

(Odds 19 : 1 = 1.99 x$\sqrt{2}$ x Standard Error of MEAN)

VARIANCE TABLE

Variation due to	Degrees of freedom	MEAN SQUARES Gross sugar	Tons beets	Percent sucrose
Between varieties	11	3,402,580	26.82	1.16
Between replications	7	2,129,619	12.13	0.48
Remainder (Error)	77	416,261	2.11	0.38
Total	95			
Calculated F value		8.17**	12.71**	3.05**

**Exceeds the 1% point of significance (F = 2.49)

VARIETY TEST, SAN ARDO, CALIFORNIA, 1960

(4 replications of each variety) By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
863H5	7503H1 x 663	11,120	36.0	15.5	164
F56-66H2	US H4	10,828	30.6	17.7	165
887H5	(MS of NB6 x NB5) x 787	10,500	33.0	15.9	179
F58-86H7	US H3	10,452	30.6	17.1	192
368	US 75	10,242	30.5	16.8	170
9921H2	(MS of NB1 x NB4) x H3611	10,137	29.8	17.1	158
General MEAN of all varieties		10,546	33.1	16.7	Beets per 100' row
S.E. of MEAN		431	1.24	0.23	
Significant Difference (19 : 1)		N.S.	3.73	0.69	
S.E. of MEAN in % of MEAN		4.9	3.7	1.4	

(Odds 19 : 1=2.131 x$\sqrt{2}$ x Standard Error of MEAN)

VARIANCE TABLE

Variation due to	Degrees of freedom	MEAN SQUARES Gross sugar	Tons beets	Percent sucrose
Between varieties	5	544,280	36.84	4.50
Between replications	3	284,298	1.53	0.25
Remainder (Error)	15	744,556	6.12	0.21
Total	23			
Calculated F value		N.S.	6.02**	21.43**

**Exceeds the 1% point of significance (F = 4.56)

VARIETY TEST, CLARKSBURG, CALIFORNIA, 1960

(2 replications of each variety) By American Crystal Sugar Co.

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Ave.wt. per beet Pounds	Harvest Count Number
9953-4	(6515HO x 7569)x D 38 (4n)	9,250	39.50	11.71	2.55	119
9952-2	(NB1 x NB4)x D 13 (4n)	9,175	34.60	13.26	1.63	163
9953-8	(6515HO x 7569)x F 13 (4n)	9,000	38.45	11.70	2.85	103
9561H5	F58-85HO x C9561	8,980	33.55	13.38	2.35	109
Polybeta	German polyploid	8,980	32.68	13.74	1.68	149
9952-4	(NB1 x NB4)x D 38 (4n)	8,800	35.93	12.25	2.36	117
9951-2	(NB1 x NB3)x D 13 (4n)	8,715	34.88	12.49	2.45	109
58-205-0	NB American #5 Elite	8,500	28.58	14.87	1.50	145
F59-507H1	58-515HO x C 8507 rr	8,320	26.88	15.48	1.33	155
9951-1	(NB1 x NB3)x D 10 (4n)	8,255	36.48	11.32	2.43	115
9921H1	(NB1 x NB3)x H 3611 (4n)	8,025	33.73	11.90	2.04	126
Am#5	Commercial variety	7,980	30.50	13.08	1.85	126
9921H3	(6515HO x 7569)x H 3611 (4n)	7,905	30.93	12.78	1.69	140
Am#2	Commercial variety	7,805	28.35	13.77	1.69	128
F59-63H2	(NB1 x NB5)x C 663	7,635	29.30	13.03	1.58	142
Hybrid #4	(NB1 x NB2)x 15-202	7,630	27.75	13.75	1.41	151
9921H2	(NB1 x NB4)x H 3611 (4n)	7,590	31.38	12.10	1.90	126
F59-63H3	(NB1 x NB4)x C 663	7,520	29.48	12.76	1.62	140
886H1	(6515HO x 7569)x C 586	7,505	26.03	14.42	1.24	161
F59-509H1	NB1 x NB3	7,415	26.48	14.00	1.39	145
Hybrid #5	(NB1 x NB3)x 51-202	7,145	27.60	12.94	1.51	140
US H2	(NB1 x NB3) x C 663	7,025	26.68	13.17	1.44	142
F59-63H4	(7515HO x 7569)x C 663	6,915	26.15	13.22	1.52	132
US 75	Commercial variety	6,850	26.73	12.82	1.29	159
F59-507H2	C 8569HO x C 8507 rr	4,955	16.40	15.11	1.11	113
General MEAN		7,915	30.36	13.04	1.73	134 Beets per 100' row
LSD 5%		2,156	7.71	1.18		
LSD 1%		2,921	10.45	1.60		
F. Value		-	3.54**	6.96**		
C. V. %		13.06	12.31	4.36		

*Exceeds the 5% point of significance (F = 1.98)
**Exceeds the 1% point of significance (F = 2.66)

Cooperator : Heringer - Holly
Location : Holland - (Stamm Ranch)
Planted : February 16 - 17, 1960
Harvested : August 16 - 18, 1960
Experimental
design: 25 x 2 Randomized Block

PERFORMANCE OF POLYPLOID VARIETIES IN CALIFORNIA

J. S. McFarlane and I. O. Skoyen

Polyploid sugar beet varieties have proved superior to open-pollinated varieties in many parts of Europe and are being grown extensively, particularly in the southern part of the continent. Experience with polyploids is limited in the United States and there is no clear-cut evidence that they perform better than do diploid hybrid varieties. The development of polyploid varieties is very costly. Not only is a great amount of work involved in producing and testing tetraploids, but isolation requirements for increasing tetraploid seed are more exacting than for diploid seed.

Additional information is needed on the comparative performance of diploid and polyploid varieties before decisions can be made regarding the amount of emphasis to place on the development of polyploid varieties. Results obtained in Europe show that triploids perform better than do other forms of polyploids. Triploid hybrids can be produced by crossing our diploid male-sterile parents with high performing tetraploids developed in Europe.

Co-operative arrangements have been entered into between the U. S. Agricultural Research Station at Salinas and Bush Johnsons Limited in England and also the Hilleshog Sugar Beet Breeding Institute in Sweden, to produce and test triploid hybrids. Three bolting-resistant diploid male-sterile parents were furnished to Dr. Ellerton of Bush Johnsons Limited. Included were MS of NB1 x NB3, MS of NB1 x NB4 and the monogerm MS of 7515 x 7569. Dr. Ellerton produced 24 triploid hybrids using the three diploid male steriles from Salinas and 8 tetraploids from his own breeding program. A portion of the seed of these 24 triploid hybrids and also of the tetraploid parents was sent to Salinas for testing.

The same three male-sterile parents were furnished to Dr. Bernstrom of the Hilleshog Sugar Beet Breeding Institute and he furnished tetraploid parents to the Salinas station. Triploid hybrids between the three male steriles and one of the Swedish tetraploids were produced at Salinas. These three triploid hybrids were tested by the USDA, by the four California sugar companies, and by the Hilleshog Sugar Beet Breeding Institute.

The triploid hybrids and their parents were evaluated in two 6 x 6 triple lattice tests, planted at Salinas on December 16, 1959 and February 23, 1960. Good stands were obtained in both dates of planting. No damage was caused by either curly top or downy mildew. The results of these tests are shown on pages 178 and 179.

POLYPLOID EVALUATION TESTS,
SALINAS, CALIFORNIA, 1960.

Location: Spence Field of the U. S. Agricultural Research Station.

Soil type: Sandy loam.

Previous crops: 1957, sugar beets; 1958 and 1959, barley cover crop.

Fertilizer used: 700 lbs. per acre 10:10:5, preplant.
400 lbs. per acre ammonium sulfate sidedressed on both tests April 1, 1960.
200 lbs. per acre ammonium sulfate sidedressed on test 2 June 9, 1960.

Planting dates: Test 1, December 16, 1959.
Test 2, February 23, 1960.

Thinning dates: Test 1, February 24, 1960.
Test 2, March 29, 1960.

Harvest dates: Test 1, August 30-31, 1960.
Test 2, October 11, 1960.

Irrigations: At 7- to 10-day intervals with sprinkler system.

Diseases and insects: Infection with yellows viruses was moderate during the 1960 season. A moderately heavy infestation of leaf miner occurred during June and July, causing some defoliation of plants. Sprayed Tests 1 and 2 with Systox and Dieldrin on June 8 for control of leaf miner. Test 2 sprayed again on July 8 with Systox and Dylox.

Experimental design: 6 x 6 Triple lattice design for both Test 1 and Test 2. Analysis of the data from Test 1 as a triple lattice showed no significant gain in accuracy over the randomized block analysis. The randomized block analysis was used in the summary tables for both Test 1 and Test 2.
Varieties included in the tests were planted in two-row plots with rows spaced 28 inches apart. Plots 29 feet long.

Sugar analysis: From two ten-beet samples per plot by Spreckels Sugar Company, Spreckels, California.

POLYPLOID EVALUATION TEST, SALINAS, CALIFORNIA, 1960

Planted February 23, 1960
Harvested October 10, 1960

(6 x 6 Triple Lattice design)

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
9953-6	7569HO x E10	11,557	38.6	15.0	147
9951-2	(MS of NB1 x NB3) x D13	11,503	36.6	15.7	140
9954-4	D38/59 (Tetraploid)	11,107	38.3	14.5	157
9954-3	D18/59 (Tetraploid)	11,051	36.3	15.3	153
9951-1	(MS of NB1 x NB3) x D10	11,001	37.2	14.8	148
9953-4	7569HO x D38	10,992	36.8	15.0	131
9954-7	E33/59 (Tetraploid)	10,969	36.0	15.2	152
9952-7	(MS of NB1 x NB4) x E33	10,941	37.5	14.7	147
9954-5	D43/59 (Tetraploid)	10,886	38.4	14.2	133
9953-2	7569HO x D13	10,859	34.1	15.9	134
9952-4	(MS of NB1 x NB4) x D38	10,776	35.6	15.1	148
9954-1	D10/59 (Tetraploid)	10,662	34.3	15.6	160
9953-3	7569HO x D18	10,607	35.5	14.9	148
9952-5	(MS of NB1 x NB4) x D43	10,586	36.6	14.6	143
9953-8	7569HO x F13	10,531	34.7	15.2	150
9954-6	E10/59 (Tetraploid)	10,507	34.8	15.1	152
9953-7	7569HO x E33	10,388	34.4	15.2	164
9953-5	7569HO x D43	10,377	35.4	14.7	136
9952-8	(MS of NB1 x NB4) x F13	10,370	36.1	14.4	122
9952-1	(MS of NB1 x NB4) x D10	10,293	35.8	14.4	150
Polybeta	German Polyploid	10,225	32.6	15.7	147
9954-2	D13/59 (Tetraploid)	9,909	32.3	15.3	143
9952-2	(MS of NB1 x NB4) x D13	9,904	33.1	14.9	134
9952-3	(MS of NB1 x NB4) x D18	9,861	34.0	14.5	147
9954-8	F13/59 (Tetraploid)	9,801	34.0	14.4	145
8943	H4213 (Swedish Polyploid)	9,583	31.7	15.1	147
9921H3	7569HO x H3611	9,523	29.9	15.9	157
863H5	7503H1 x 663	9,343	32.7	14.3	131
F58-554H1	(MS of NB1 x NB4)	8,649	29.4	14.7	141
9921H2	(MS of NB1 x NB4) x H3611	8,551	28.2	15.2	157
9950	H5859 (Swedish Polyploid)	8,497	28.4	14.9	134
9921	H3611 (Swedish Tetraploid)	8,379	27.3	15.3	129
9921H1	(MS of NB1 x NB3) x H3611	8,307	27.6	15.1	153
F58-509H1	(MS of NB1 x NB3)	8,069	26.7	15.1	129
7569HO	5515HO x 7569 (mm)	7,971	25.0	15.9	143
368	US 75	7,944	27.4	14.5	141
General MEAN of all varieties		10,013	33.4	15.0	Beets
S. E. of MEAN		490	1.66	0.35	per
Significant Difference (19:1)		1,387	4.69	N.S.	100"
S. E. of MEAN in % of MEAN		4.9	5.0	2.3	row

(Odds 19:1 = 2 x $\sqrt{2}$ x Standard Error of the MEAN)

VARIANCE TABLE

Variation due to	Degrees of freedom	MEAN SQUARES Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	35	3,416,615	42.21	0.67
Between replications	2	5,591,863	99.51	1.66
Remainder (Error)	70	721,677	8.24	0.36
Total	107			
Calculated F Value		4.73**	5.12**	N.S.

**Exceeds the 1% point of significance (F = 1.93)

POLYPLOID EVALUATION TEST, SALINAS, CALIFORNIA, 1960

(6 x 6 Triple lattice design)

Planted December 16, 1959
Harvested August 30-31, 1960

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	Harvest Count Number
9951-2	(MS of NB1 x NB3) x D13	13,566	45.2	15.0	13.5	148
9954-4	D38/59 (Tetraploid)	13,021	44.3	14.7	10.4	140
9951-1	(MS of NB1 x NB3) x D10	12,969	42.1	15.4	12.5	141
9952-5	(MS of NB1 x NB4) x D43	12,908	42.8	15.2	7.5	148
9953-6	7569HO x E10	12,759	42.4	15.1	6.9	138
9953-5	7569HO x D43	12,624	42.6	14.8	5.2	124
9954-3	D18/59 (Tetraploid)	12,503	42.9	14.6	6.0	143
9953-8	7569HO x F13	12,438	40.8	15.3	5.1	136
9954-6	E10/59 (Tetraploid)	12,342	41.6	14.8	5.9	134
9954-5	D43/59 (Tetraploid)	12,143	41.2	14.8	4.4	143
9954-8	F13/59 (Tetraploid)	12,099	39.9	15.2	3.0	150
9953-4	7569HO x D38	12,016	40.5	15.0	8.6	134
863H7	(MS of NB1 x NB4) x 663	12,016	40.2	15.0	16.8	153
9954-7	E33/59 (Tetraploid)	12,015	39.9	15.1	4.5	148
9952-7	(MS of NB1 x NB4) x E33	11,987	42.1	14.2	4.4	145
9954-2	D13/59 (Tetraploid)	11,967	38.8	15.5	4.2	150
9952-1	(MS of NB1 x NB4) x D10	11,879	40.8	14.6	9.1	152
F58-554H1	(MS of NB1 x NB4)	11,694	39.9	14.7	5.6	162
9954-1	D10/59 (Tetraploid)	11,668	38.0	15.4	7.4	145
9952-3	(MS of NB1 x NB4) x D18	11,616	39.0	15.1	8.5	153
9953-2	7569HO x D13	11,550	37.8	15.4	11.1	141
9952-2	(MS of NB1 x NB4) x D13	11,456	38.3	14.9	8.0	153
787H1	(MS of NB1 x NB4) x 787	11,440	37.4	15.3	4.4	147
9952-8	(MS of NB1 x NB4) x F13	11,277	38.3	14.8	7.0	148
Polybeta	German Polyploid	11,273	36.3	15.5	20.6	150
9953-3	7569HO x D18	11,168	36.7	15.3	9.4	140
9952-4	(MS of NB1 x NB4) x D38	11,149	37.6	14.9	13.1	162
9953-7	7569HO x E33	10,981	36.8	14.9	6.5	128
9921H2	(MS of NB1 x NB4) x H3611	10,801	34.5	15.7	12.7	160
9950	H5859 Swedish Polyploid	10,467	34.0	15.4	22.6	143
F58-509H1	(MS of NB1 x NB3)	10,458	34.1	15.4	3.2	162
9921H3	7569HO x H3611	9,960	31.9	15.6	20.9	150
368	US 75	9,917	32.8	15.2	3.3	153
9921H1	(MS of NB1 x NB3) x H3611	9,916	31.8	15.7	38.4	145
8943	H4213 Swedish Polyploid	9,665	33.4	14.5	40.5	128
7569HO	(5515HO x 7569) (mm)	9,628	29.9	16.2	13.3	152
General MEAN of all varieties		11,593	38.5	15.1	10.7	Beets per 100' row
S. E. of MEAN		545	1.81	0.35	2.13	
Significant Difference (19:1)		1,542	5.11	N.S.	6.01	
S. E. of MEAN in % of MEAN		4.7	4.7	2.3	19.9	

(Odds 19:1 = 1.994 x $\sqrt{2}$ x Standard Error of MEAN)

VARIANCE TABLE

Variation due to	Degrees of freedom	MEAN SQUARES Gross Sugar	Tons Beets	Percent Sucrose	Percent Bolting
Between varieties	35	3,052,499	43.17	0.46	227.47
Between replications	2	11,754,534	285.23	6.01	84.54
Remainder (Error)	70	891,855	9.79	0.35	13.59
Total	107				
Calculated F Value		3.42**	4.41**	N.S.	16.74**

**Exceeds the 1% point of significance (F = 1.93)

Yellows infection occurred in April and May and undoubtedly caused some yield reduction. The triploid hybrids varied greatly in their yielding ability but there was no significant difference in sucrose percentage in either the December or February planted tests. In the December planting the highest performing variety was a triploid between MS of NB1 x NB3 and one of Dr. Ellerton's tetraploids. This hybrid produced 45.2 tons per acre with 15.0 percent sugar. The poorest triploid yielded 31.8 tons per acre with 15.7 percent sugar. In the February planting a triploid hybrid between the monogerm male sterile and a tetraploid developed by Dr. Ellerton yielded 38.6 tons per acre with 15.0 percent sugar. The poorest triploid in this test yielded 27.6 tons per acre with 15.1 percent sugar.

Five tetraploids in the December planting and six tetraploids in the February planting were among the highest yielding varieties. Each of the diploid male-sterile parents was inferior to one or more of the triploids and tetraploids in yielding ability. Although the tests were not designed to compare diploid and triploid hybrids, there was a trend for the better triploid hybrids to outyield the few diploid hybrids which were included. There was no difference in the sucrose percentage of the diploid and triploid hybrids. The German polyploid variety, Polybeta, and two Swedish polyploid varieties (not triploids) failed to yield as well as did the better triploids.

Three triploid hybrids utilizing Dr. Ellerton's tetraploids as the male parents were included in a Union Sugar variety test at King City. The yields and sugar percentages of these three triploids were not significantly different from those of the better diploid hybrids. The triploid (MS of NB1 x NB4) x Ellerton's D13 tetraploid was included in a Salinas variety test (7 replications) and was not significantly different from the better diploids in either root yield or sugar percentage.

The three triploid hybrids utilizing the Swedish tetraploid, H3611, as the male parent were included in several variety tests. The performance of two of these triploids and of US H6 expressed in percent of US 75 has been summarized from seven tests:

	Gross Sugar	Percent Sucrose
(MS of NB1 x NB4) x H3611	114	103
(MS of 7515 x 7569) x H3611	110	103
US H6	117	102

The three triploid hybrids which utilized H3611 as the male parent were evaluated for curly-top resistance at Jerome, Idaho. All three triploids lacked resistance and were damaged as much or more than the US 33 variety.

GAMETOCIDE TEST ON SUGAR BEETS

I. O. Skoyen

Field testing was continued during 1960 on the effectiveness of 2, 3-dichloroisobutyrate (Rohm and Haas, FW 450) as a gametocide on sugar beets.

Materials and Procedures

The field test was conducted in a planting made September 16, 1959. The planting was made using a factorial design according to proposals set out in a memorandum, from Mr. Stewart's office. A breeding line with green hypocotyl, SP 579-01rr, was planted for testing with FW 450. A red beet derivative developed by Holly Sugar Corporation for use as a plot marker and top cross parent was planted as a pollen source. Each row of the green hypocotyl number was separated by two or three rows of the red beet. In all, the plot contained 24 rows, including six of SP 579-01rr. The rows were 87 feet long. The test was planted on single-row beds with 28-inch centers. The rows were thinned to a six-inch spacing between plants and the rows divided into six 12-foot plots. This provided 36 treatment plots as required for a 3^2 factorial design with four replications.

Three levels of FW 450 were applied at intervals of 5, 10 and 15 days. The FW 450 was applied to near runoff, as an aqueous solution, at concentrations of 0.15, 0.22 and 0.3 percent. The first applications were made on June 10, 1960, when new flower branches were in early bud.

Originally it was planned to obtain seed yields in addition to information on seed viability and on the effectiveness of FW 450 as a gametocide. Unfortunately, SP 579-01rr commenced bolting in late March, and it was necessary to cut back the seedstalks until pollen from the red beets was available. Plants of SP 579-01rr, therefore, were cut back for slightly over two months, eliminating the possibility of obtaining reliable results on the seed yield of treated plants.

Plants of the red beet were treated three times with gibberellic acid in an effort to hasten bolting and flowering. Concentrations of 400 to 500 ppm were sprayed on, to runoff, at weekly intervals for the first two applications and at a three-week interval for the third. The center row of the red beet strips was not sprayed in order to provide a check on the effectiveness of the gibberellic acid. Counts of the red beet on July 19, 1960, showed 8 percent more plants shedding pollen in the treated rows than in the check row. Overall, 22 percent of the red beets eventually shed pollen.

During the course of the experiment, observations were made on the development and duration of sterility choosing a different replication for each observation. Each treatment in the remaining replications was

compared with the one observed in most detail to determine similarity among replications. The degree of sterility was judged on the basis of the number of anthers shedding pollen as well as by the size and color of the anthers on treated plants. A total of six observations were made at one- to two-week intervals from June 25 to August 22, 1960.

Treated plots were harvested September 12-13, 1960. All the plants of a given treatment were bulked in each of the replications.

Plants of SP 579-01rr and the red beet derivative also were transplanted from the test plot to an isolation to provide a check on natural cross pollination. The check plot was planted March 28, 1960.

Results

Results of the field test (Table 1) show that a high level of cross-fertilization was obtained with FW 450 for all concentrations and intervals of application. The general mean was 81.3 percent, whereas the range of the replication averages, for all concentrations and intervals, was 75.2 to 84.5 percent. Factorial analysis of the data on hybridization, excluding the check, showed no significance between either concentrations of the gametocide or intervals of application, nor was interaction indicated between concentrations and intervals. The check showed 11.4 percent crossing with red beet indicating that, in the Salinas area, SP 579-01rr was not highly self fertile.

Germination percentages (Table 1) were generally high for all treatment intervals and concentrations of FW 450. The results showed germination to be slightly reduced with each increase in interval between treatments. The replication averages for all concentrations and intervals ranged from 71.5 to 88.0 percent with a general mean of 79.3 percent. The check germinated 94 percent which was 6 to 22.5 percent higher than for treated plots. Factorial analysis of the data (Table 2), excluding the check, indicated a significant difference between treatment intervals at the 5-percent level of F but no significance between concentrations. However, t-tests applied to the treatment interval totals, for each concentration of FW 450, showed no significance for reduction in germination with increased interval between treatments. The t values approached significance at the 5-percent level. Considering the reduction in germination with increase in the interval between treatments, it is seen (Table 1) that germination of seed from the 10-day interval averaged 4.0 to 8.5 percent lower than that of seed from the 5-day interval. The 15-day interval, in turn, averaged 2.0 to 7.0 percent lower than the germination percentage of seed from plots treated at 10-day intervals.

Data on seed yield was included in Table 1 to show only the trend toward reduced yield from treated plots as concentration was increased. As mentioned earlier, plants of SP 579-01rr were cut back and this made it impossible to obtain reliable yield data.

Table 1.--Summary of percent hybridization, percent germination, and seed yield obtained in 1960 gametocide test.

	Concentration and interval										General MEAN (excluding check)
	Check	15%			0.22%			0.3%			
		5 day	10 day	15 day	5 day	10 day	15 day	5 day	10 day	15 day	
Percent red seedlings	11.4	78.1	77.4	84.5	81.9	81.4	83.1	75.2	84.0	83.7	81.3
Percent germination	94.0	88.0	79.5	77.5	83.0	78.5	71.5	83.5	79.5	73.0	79.3
Seed yield (grams)	52.6	53.3	32.6	46.2	38.5	27.0	28.9	30.9	21.9	22.4	33.5

Table 2.--Factorial analysis of percentage germination of seed harvested from plots of SP 579-01rr treated with FW 450.

Conc. FW 450	Treatment Interval	Replications I	II	III	IV	Total	Average
0.15%	5 day	90	84	90	88	352	88.0
"	10 day	66	80	72	100	318	79.5
"	15 day	56	70	94	90	310	77.5
						980	81.7
0.22%	5 day	80	80	88	84	332	83.0
"	10 day	70	82	74	88	314	78.5
"	15 day	70	72	68	76	286	71.5
						932	77.7
0.3%	5 day	84	78	82	90	334	83.5
"	10 day	70	72	88	88	318	79.5
"	15 day	74	56	88	74	292	73.0
						944	78.7
						G = 2856	79.3

VARIANCE TABLE

Variation due to	Degrees of Freedom	Sums of Squares	MEAN Square	Calc. F value	Tabular 5% value
Total	35	3632			
Replications	3	1057	352.3	4.89*	3.01
Treatments	8	846	105.8	N.S.	-
Concentrations	2	92	46.0	N.S.	-
Spray intervals	2	705	352.5	4.90*	3.40
Conc. X intervals	4	49	12.3	N.S.	-
Error	24	1729	72.0		

Phytotoxic effects of the chemical appeared to follow generally the same pattern as observed in previous tests. Increased concentration produced progressively greater damage to leaf and stem tissue. Damage to leaf and stem tissue occurred as contact burn, development of chlorosis, leading to necrosis of severely chlorotic areas, and distortion of leaves and flower parts. Distortion responses to FW 450 usually were shown as thickening of sepals, bracts and leaves. Severe thickening of sepals made the flowers appear closed except on close inspection. Bracts appeared to be several times thicker in cross section than normal.

Observations on sterility indicated that the maximum level of sterility developed within 10 to 20 days of the initial application of FW 450 for each of the three concentrations. Sterility appeared to be fully developed by the time the final application was made. The degree of pollen sterility increased as the concentration of FW 450 increased. Plants which received the 0.15-percent concentration were never completely emasculated during the period of observation, but pollen shedding anthers were few and scattered, for all treatment intervals for a period of 35 to 45 days after the final application of FW 450. Anther development required an additional 15 to 20 days to return to normal. Treated plants appeared to be fully recovered from the effects of the chemical about 60 days after the final treatment with FW 450.

Plants treated with the 0.22-percent concentration of FW 450 were also highly sterile for 35 to 45 days after the last treatment with FW 450. However, return to normal pollen development was more gradual and plants were not yet fully recovered 65 days after the last treatment. Plants were judged highly sterile if no shedding anthers were found or if only occasional anthers were found to be shedding pollen. Plants treated at 10- and 15-day intervals showed the highly sterile stage for the longest period.

Plants treated with the 0.3-percent concentration remained highly sterile somewhat longer than those treated with lower concentrations. Only occasional anthers were found to be shedding pollen 40 to 50 days after the last application of the chemical. The period in which the plants appeared to be completely sterile was also extended about 10 days for the 15-day treatment interval and slightly less for the 10-day interval. Pollen shedding was still low 65 days after the last application of FW 450.

Summary

The 1960 field results of testing with FW 450 indicated that approximately 80 percent hybridization occurred on plants treated with the chemical. Analysis of the percent hybridization showed no significant differences between concentration, or between intervals. Mean germination of seed produced on treated plots was nearly 15 percent below that of seed produced on check plants. Percentage germination decreased with each concentration of FW 450 as the treatment interval was increased from 5 to 15 days, although

by the t-test this was not significant. Yield, although not reliable in the 1960 test, was found to be severely reduced in earlier tests.

Observations on the period of sterility in the 1960 test showed that sterility was fairly effective for 30 to 50 days. Periods of complete sterility were observed in plants treated with the 0.22-and 0.3-percent concentrations of FW 450. The level of pollen sterility increased with both increased concentration of FW 450 and treatment interval.

Phytotoxic side effects such as contact burn, chlorosis followed by necrosis, and distortion of leaves and flower parts generally followed the same pattern as observed in previous tests with FW 450.

When FW 450 is used on a field basis a fairly high level of hybridization can be obtained. However, a few flowers nearly always produce pollen which means that the seed is seldom completely hybrid. Phytotoxic effects of the chemical cause reduced seed production and germination. For these reasons the commercial use of FW 450 on sugar beet seems impractical.

FW 450 offers its greatest promise as a breeding tool. For example, when it is desirable to produce a small quantity of hybrid seed for evaluation purposes a few plants of one of the parents can be emasculated with FW 450. In this way it provides a convenient method of crossing self-fertile plants.

POLYPLOIDY AND INTERSPECIFIC HYBRIDIZATION

B. L. Hammond

During the past year, concentrated effort has been placed on producing polyploid strains of sugar beets to determine their value for the West Coast area.

Sixteen plants from a population of colchicine-treated seedlings of the top-cross parent, 663, were selected as being highly tetraploid chimeras on the basis of chromosome counts of vegetative tissue and then exposed to thermal induction for 126 days. Prior to flower opening, chromosomes of the young vegetative tissues of the flowering stalks were counted. Thirteen of those showing predominantly tetraploid tissue were selected for interpollination. A portion of the harvested seed was sown in Oregon in July to produce plants for chromosome determination and for seed increase at Salinas. In addition, another lot of this seed was sown recently in the Salinas greenhouse, from which 278 plants were obtained. To date, chromosomes have been checked on 165 plants--135, or approximately 82%, of these being tetraploid. When chromosome counts are completed, all tetraploid plants will be exposed to thermal induction and isolated for further seed increase.

Forty-six colchicine treated plants of the highly promising multigerm inbred, 0539, were selected and exposed to thermal induction. These are now in the greenhouse for chromosome determinations and selfing.

The chromosomes of all the progenies of 61 T8-Line single-plant selections which had been selected on the basis of pollen size and chloroplasts counts have been checked. The progenies of 53 of the 61 were tetraploids and are now being grown for seed increase. The T8 line is a group of tetraploid plants which were produced from S_6(US 22/3 x NB1).

The production of monogerm tetraploids also has received attention. Crosses will be made between the colchicine-treated, cytoplasmic male-sterile 9561H2 and the monogerm inbred, 0562. The colchicine-treated seedlings of these selections are now under thermal induction. A similar treatment is being given Dr. Owen's diploid monogerm lines, SL 0267 and SL 0156.

Two hundred and thirteen grams of good seed were obtained as a result of cross pollination between B. vulgaris and B. Webbiana, and 52 grams of seed were obtained from B. vulgaris and B. procumbens. Attempts to cross the tetraploid SL 340 and B. patellaris failed to yield any good seed. These crosses were made for use in breeding sugar beets for nematode resistance.

PART VIII

PRODUCTION OF BASIC BREEDING MATERIAL
and
DEVELOPMENT OF BREEDING PROCEDURES

Foundation Project 25

LeRoy Powers

R. E. Hecker

PROGRESS REPORT TO THE BEET SUGAR DEVELOPMENT FOUNDATION ON THE GENETIC AND PLANT BREEDING PHASES OF PROJECT NUMBER 25 1/

By LeRoy Powers and Richard J. Hecker

THE PARTITIONING METHOD OF GENETIC ANALYSIS APPLIED TO SUGARBEET BREEDING

INTRODUCTION

The purpose of this paper is to discuss the application of the partitioning method of genetic analysis to breeding sugarbeets.

The partitioning method of genetic analysis is based on the fact that the frequency distribution of any segregating population is composed of a number of genotypes and that individuals possessing the same genotype fluctuate about a common mean. Hence any segregating population is composed of subgroups equal in number to the different genotypes in the population. It follows that there are subgroup means, subgroup frequency distributions, and subgroup variances. The subgroup variances are attributable to environmental differences and may or may not be of equal magnitude. The genetic variance of a segregating population is due to the differences between means of the genotypes and can be calculated directly from the subgroup means, provided the magnitude of the means for each genotype can be determined.

The above facts provide a basis for determining by partitioning the identifiable numbers and proportions of genetic deviates in the lower and higher classes of the frequency distribution of any given population. It should be kept in mind that the proportions of all genetic deviates are not obtained by partitioning. Only the identifiable numbers or proportions of genetic deviates are determined and only for the lower and higher classes of the frequency distribution. However, these are the individuals of most interest to the plant breeder. This follows because of the extreme difficulty of isolating genetic deviates from the middle classes of the frequency distribution due to the large proportion of environmental deviates falling into these classes.

1/ The breeding and genetic phases of project 25 are cooperative with the Agronomy Department of the Colorado State University Agricultural Experiment Station.

CHARACTERS STUDIED, MATERIALS, AND METHODS

The characters studied are sucrose expressed as percentages and weight per root measured in pounds. These two characters were chosen for study because of their economic importance. Percent sucrose times weight per root gives sugar per root, and in turn, sugar per root times number of roots per acre gives yield of sugar per acre. Usually characters such as disease resistance, monogerm, etc., are found in material that has no direct application to the production of beet sugar because of low yield of sugar per acre of the material in which it occurs. Consequently, a breeding program is required to incorporate such characters into material having sufficient yielding ability to warrant commercial production. Therefore, almost without exception percentage sucrose and weight per root play a prominent role in any breeding program.

The plant materials employed in the studies reported herein are varieties, selections, inbreds, and F_1 hybrids. In most cases the inbreds and F_1 hybrids are used to estimate the environmental variances. However, in those cases in which the genetic variances are attributable to differences between means of populations replications, groups, and duplicate entries within replications and groups are employed to estimate the environmental variances. The studies extended over a period of 5 years. Population genetic studies were conducted in 1955, 1956, and 1958. Polycross tests for combining ability were conducted in 1957, 1958, and 1959. Mother line selection was practiced in the 1957 polycross test and the selections were grown in the 1959 combining ability tests. Thirty-two selections were tested for general combining ability in 1957, 40 in 1958, and 50 in 1959.

The designs of the experiments are randomized complete blocks for the population genetic studies and groups of randomized complete blocks for the polycross tests. The population genetic studies had 80 replications in 1955 and 1958, and 40 replications in 1956. The polycross tests had 5 replications for each of all years tested. The number of groups for the different years varied from 3 to 5, there being 3 groups in 1957, 4 in 1958, and 5 in 1959. There are 12 entries per group with the exception of group 3 in 1957 which had 14 entries. Two of the entries were duplicate samples of variety A54-1. All of the selections were made from variety A54-1. Hence comparisons between the derived populations and A54-1 measure the success of the breeding program.

Methods of breeding diploid sugarbeets may be listed as follows.

1. Selection
   - A. Mass selection or some modification of it.
   - B. Mother line (Vilmorin, Louis de, 1856 [11]).
   - C. Selection from small units (Powers, 1957 [5]).

2. Polycross (Tysdal et al, 1942 [10]).
3. Recurrent selection (Hull, 1945 [3]).
4. Reciprocal recurrent selection (Comstock et al, 1949 [1]).
5. Inbreeding followed by hybridization, hybrids, being used to produce the commercial product (Shull, 1909 [9] and East and Hayes 1912 [2]).

Although the investigations at Fort Collins include a study of all these methods, data are available only for selection from small units, selection from small units followed by mother line, and polycross. However, after considering the data, an attempt will be made to show the application of the partitioning method of genetic analysis to all the methods listed above.

RESULTS

Partitioning Population Frequency Distributions to Determine the Identifiable Numbers and Proportions of Genetic Deviates

In 1955 population genetic studies were conducted with variety A54-1 for the purpose of determining the suitability of this variety for investigating methods most appropriate for breeding sugarbeets. Also, population genetic studies involving A54-1 and other populations were conducted at different levels of soil fertility in 1956. The partitioning method of genetic analysis was applied to these data to determine the identifiable numbers and proportions of genetic deviates in the lower and higher classes of the frequency distributions. In this paper the term genetic deviates is used to designate those calculated from the identifiable numbers and proportions and hence does not include all of the genetic deviates in the frequency distribution.

The means, obtained and calculated frequency distributions, and identifiable numbers and proportions of genetic deviates for percentage sucrose and weight per root are listed in tables 1 and 2, respectively. The methods of procedure are outlined in detail by Powers, Robertson, and Clark, 1958 [6] and Powers, Robertson, and Remmenga, 1958 [7] . Before discussing the data in tables 1 and 2 it should be pointed out that the calculated frequency distribution is attributable to environmental variability. It is calculated from the mean, environmental standard error, and tables of the normal probability integral. As is shown by the solid vertical lines, the classes of the frequency distributions are divided into 3 sets as follows. For table 1 the differences are positive up to and including class 15.75, are negative in classes 16.50 to 18.75, inclusive, and positive in classes 19.50 and higher. For table 2 the frequency distribution is again composed of 3 sets, the lower and higher classes having positive values and the middle classes having negative values. In this and other earlier publications the first set of classes is designated as lower classes of the frequency distribution, the second set as middle classes of the frequency distribution and the last set as higher classes of the frequency distribution. The lower and higher classes contain some identifiable proportions of genetic deviates. The method used does not estimate the proportion of genetic deviates for the middle classes. It is interesting to note that those individuals in classes having no calculated values are nearly all genetic deviates as only rarely would environmental deviates fall into these classes. Hence these are the identifiable genetic deviates. The identifiable numbers and proportions of genetic deviates are shown in the last two columns of tables 1 and 2.

Table 1. Mean, obtained and calculated frequency distributions, and identifiable numbers and proportions of genetic deviates for percentage sucrose, A54-1, non-fertilized, population genetic studies, 1956.

Distribution, difference and proportion	Mean	Upper limit of class, percent															Identifiable numbers and proportions of genetic deviates	
		0 to 11.25	12.00	12.75	13.50	14.25	15.00	15.75	16.50	17.25	18.00	18.75	19.50	20.25	21.00	21.75 and over	Lower classes	Higher classes
	%	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Obtained	17.9	3	1	0	1	4	12	11	25	36	62	66	58	26	11	4	32	99
Calculated		0	0	0	0	0	3	10	28	56	74	71	47	22	7	2	13	78
Difference		3	1	0	1	4	9	1	- 3	-20	-12	- 5	11	4	4	2	19	21
Proportion		1.00	1.00	0.00	1.00	1.00	0.75	0.09					0.19	0.15	0.36	0.50	0.59	0.21

Table 2. Mean, obtained and calculated frequency distributions, and identifiable numbers and proportions of genetic deviates for weight per root, A54-1, non-fertilized, population genetic studies, 1956.

Distribution, difference and proportion	Mean	Upper limit of class, pounds											Identifiable numbers and proportions of genetic deviates	
		0 to 0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5 and over	Lower classes	Higher classes
	Lbs.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Obtained	1.93	8	35	56	80	72	38	19	9	2	0	1	43	31
Calculated		3	17	57	99	90	42	10	2	0	0	0	20	12
Difference		5	18	- 1	-19	-18	- 4	9	7	2	0	1	23	19
Proportion		0.62	0.51					0.47	0.78	1.00	0.00	1.00	0.53	0.61

The bivariate frequency distribution for percentage sucrose and weight per root is given in table 3. For details of the earlier approach to this method of analysis see Powers, 1945 [4]. The vertical and horizontal lines within the bivariate frequency distribution are based on limits set by the vertical lines in tables 1 and 2. They are the limits for the 3 sets designated as lower classes, middle classes, and higher classes. This divides the bivariate frequency distribution into 9 sets shown by the Roman numerals. The sugarbeet breeder working with percentage sucrose and weight per root is primarily interested in sets IV, V, and VI. If attempting to increase both percentage sucrose and weight per root, interest lies in the number and proportion of individuals in set V. The number of individuals of average sucrose percentage but having increased weight per root are shown in set IV. Finally the number of individuals having average weight per root but increased percentage sucrose are shown in set VI. It is not necessary to calculate homogeneity chi squares to show that the expected and obtained numbers in sets IV, V, and VI are not materially different. The obtained number of 7 in set V indicates that by the use of appropriate breeding methods and procedures it should be possible by breeding within variety A54-1 to improve both percentage sucrose and weight per root. Further, by conducting research on different methods of breeding within A54-1 for increased sucrose and weight per root simultaneously, information of fundamental importance to the breeding of sugarbeets should be obtained. Hence, it was decided to work intensively with variety A54-1.

The data in set V for years 1955, 1956, 1958 and 1959 were used to calculate the data tabulated in table 4. Table 4 lists the estimation by years of the numbers and proportions of genetic deviates among 10,000 individuals superior for both percentage sucrose and weight per root in classes having identifiable proportions of genetic deviates. Homogeneity chi square tests applied to the numbers in column 5 and the numbers from which the proportions were calculated under sucrose and weight in column 6 provide evidence as to whether the numbers of genetic deviates in 10,000 differ between years, and between the two fertilizer treatments in 1956. Significant differences in the numbers obtained (column 5) or the proportions listed under sucrose and weight (column 6), barring compensating differences, indicate significant differences between years and treatments within 1956 as regards the numbers of genetic deviates in 10,000. The estimated numbers of genetic deviates in 10,000 are listed in the last column of table 4.

Table 3. Bivariate frequency distribution expressed in numbers for percentage sucrose and weight per root showing number of individuals in classes having identifiable proportions of genetic deviates, A54-1, non-fertilized, population genetic studies, 1956.

Percentage sucrose, upper limit of class	Weight of root, upper limit of class: 0 to 0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	Total	
%	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	
	I Expected 4 Obtained 7		II Expected 25 Obtained 18				III Expected 3 Obtained 7						
0 to 9.75				1								1	10.0000%
10.50												0	
11.25					1	1						2	
12.00					1							1	
12.75												0	
13.50			1									1	
14.25				1	1		1				1	4	
15.00	1	3	1	3	2	1			1			12	
15.75	1	2	1	1		2	2	2				11	
	VIII Expected 25 Obtained 21		IX								IV Expected 18 Obtained 17		
16.50		3	3	11	3	3	1	1				25	59.0625%
17.25	1	3	8	8	6	6	2	2				36	
18.00	3	5	7	17	16	7	5	1	1			62	
18.75	1	5	7	18	21	10	2	2				66	
19.50	1	10	18	9	11	5	3	1				58	30.9375%
20.25		4	4	6	9	1	2					26	
21.00			5	2	1	2	1					11	
21.75			1	1								2	
22.50				2								2	
	VII Expected 13 Obtained 15		VI Expected 76 Obtained 77				V Expected 10 Obtained 7						
Total	8	35	56	80	72	38	19	9	2	0	1	320	
	13.4375%		76.8750%				9.6875%						

Table 4. Estimation by years of identifiable numbers and proportions of genetic deviates among 10,000 superior for both percentage sucrose and weight per root in higher classes having identifiable proportions of genetic deviates, population A54-1.

Year and treatment	Number of plants in population (n)	Root over 1/ Sucrose	Root over 1/ Weight	Number obtained (x)	Identifiable proportion of genetic deviates in x (y)	Number of genetic deviates in population (xy)	Proportion of genetic deviates in population (xy/n)	Number of genetic deviates in 10,000
	No.	%	Lbs.	No.	Suc. Wt. Pro.	No.	Pro.	No.
1955	520	13.50	8.0	8	(0.36 X 0.46)=0.1656	1.3248	0.002548	25
1956								
Fertilized	320	17.25	3.5	9	(0.09 X 0.38)=0.0342	0.3078	0.000962	10
Non-fert.	320	18.75	3.0	7	(0.21 X 0.61)=0.1281	0.8967	0.002802	28
1958	320	17.25	4.5	4	(0.26 X 0.59)=0.1534	0.6136	0.001918	19
1959	320	14.25	4.0	1	(0.59 X 0.68)=0.4012	0.4012	0.001254	13

1/ Classes having values greater than those listed in these two columns have some identifiable numbers and proportions of genetic deviates.

Homogeneity chi square calculated from the data of column 5 is 7.205 and P lies between 0.20 and 0.10. The two chi square values calculated from the numbers giving the proportions listed under sucrose and weight in column 6 are 50.1388 and 10.0513, respectively, and the corresponding P values lie between 0.01 and 1-infinity and between 0.02 and 0.01. For fertilizer treatments within the year 1956 the two chi square values are 7.2895 and 4.3494 and the corresponding P values lie between 0.01 and 1-infinity and 0.05 and 0.02. For testing the differences between years, the two fertilizer treatments were combined to make a population composed of 640 individuals. Since an examination of the data in table 4 does not reveal compensating differences, the data are fairly conclusive in showing that the number of genetic deviates in 10,000 calculated from the identifiable proportions of genetic deviates is not the same for all years or for fertilizer treatments in the same year. This may be taken as indicating that breeding for both high percentage sucrose and weight per root would be more effective for some years than for others. The same is true as regards fertilizer treatments. However, as regards fertilizer treatments, other considerations make it seem desirable to do the breeding work at the level of soil fertility at which it is anticipated the crop will be grown (see Powers, Robertson, Whitney, and Schmehl, 1958 [8]). Probably one of the most important conclusions to be drawn from the data of table 4 is that some genetic deviates occur in the desirable classes every year and in both fertilizer treatments. The range was from 10 to 28 genetic deviates in 10,000.

Selection from Small Units, Polycross Tests, and Population Genetic Studies

The population genetic studies conducted in 1955 showed A54-1 to have a high identifiable proportion of genetic deviates and considerable genetic variability. Therefore, A54-1 was selected to start the research on methods of breeding sugarbeets.

In 1956 three selections were made at two fertility levels from small units planted for that purpose. For the method of selection from small units see Powers, 1957 [5]. The two fertility levels are termed high fertility (hi) and low fertility (lo). The high fertility plots received a surface application of 100 pounds of N and 250 pounds of P_2O_5 per acre on April 4, 1956. The fertilizer was cultivated under with a rototiller. The material from which the selections were made was planted on April 10 and 11. On June 26 another 100 pounds of N per acre was drilled into the center of each space between rows of the fertilized plots. The low fertility plots did not receive an application of fertilizer. Analysis of petioles just before harvest showed the petioles from the low fertility plots to be decidedly lower in nitrate nitrogen than those from the high fertility plots.

The size of the plots from which the two selections designated as hi fertility and lo fertility were made was six rows with 24 plants per row. There were 40 such units for each selection, making a potential of 5,760 plants in each from which the two selections were made. In the third

selection experiment there were 12 rows of 24 plants each and again there were 40 such units, making a potential of 11,520 plants from which this selection was chosen. In all three selection experiments nearly perfect stands were obtained at the time of thinning. There were a few plants lost during the growing season. However, excellent stands remained at the time of harvest and only competitive roots were selected; that is, beets which had beets growing on four sides of them. In selecting, emphasis was first placed on weight per root and then secondly on percentage sucrose. In the hi and lo experiments 40 roots were saved from each for polycross tests. The two lots of seed harvested from the polycross plots are designated as Selection A54-1 Hi and Selection A54-1 Lo. In the third experiment, seed from 32 roots was saved from the polycross plot. The progenies of these 32 roots were grown in a polycross test in 1957 and 20 competitive beets were harvested from the center row of each 3-row plot. These 20 competitive plants from each plot were trimmed as mother beets, and the percentage sucrose and weight per root were taken on the basis of individual plants. Taking the data on the basis of individual plants made possible population genetic studies pertaining to the evaluation of breeding methods. Mother line selection was practiced among the progeny of these mother beets. In this case emphasis was first placed on percentage sucrose and secondly on weight per root. Fifty-five roots were finally saved from the total of 3200 beets in the polycross test. The final elimination to 55 mother beets was on the basis of the performance of the mother beet progenies of which they were members. These beets were grown in a polycross isolation plot and fifty of them progeny-tested for general combining ability in 1959.

Also the 10 asexually propagated mother beets showing the best performance in the 1957 polycross test as regards percentage sucrose and weight per root were grown in the greenhouse during the winter of 1957-58 and interpollinated. The seed was harvested on an individual plant basis. Equal amounts of seed from each of the 10 plants were bulked and thoroughly mixed to produce the material designated as Selection A54-1 Synthetic.

Means

The means and the means expressed as percent of A54-1 for percentage sucrose and weight of roots per plot for 1957 and 1958 polycross tests are listed in table 5. When evaluating the data in table 5, it is helpful to have in mind that the selections were chosen first for large size root and secondly for high percentage sucrose. Also it is necessary to have in mind that the material tested is not the same for the two years. The polycross for 1957 was from open-pollinated seed of 32 mother beets selected from a total of approximately 11,520 plants grown at a low fertility level, whereas the polycross for 1958 was from open-pollinated seed of 40 mother beets selected from a total of approximately 5,760 plants grown at a high fertility level. The data for percentage sucrose furnish no evidence of either an increase or a decrease of the two different selections over the material from which they were derived, namely A54-1. The selections show an increase in weight per root of 7.1 percent in 1957 and 6.1 percent in 1958. This increased difference in weight of root is well established statistically.

Table 5. Means and means expressed as percent of A54-1 for percentage sucrose and weight of roots per plot, 1957 and 1958 polycross tests.

Character and population	Year 1957 Mean	Percent of A54-1	1958 Mean	Percent of A54-1
Sucrose, %				
Selections	15.1	100.0	15.3	98.1
A54-1 (check)	15.1		15.6	
Weight, Lbs.				
Selections	40.22*	107.1	33.99*	106.1
A54-1 (check)	37.56*		32.03*	

* Application of the t test showed that the odds against the difference between the mean of the selections and the mean of A54-1 for each year being due to chance is greater than 99:1.

Table 6. Means for percentage sucrose, weight per root, and sugar per root; population genetic studies, 1958.

Population	Percentage sucrose		Weight per root		Sugar per acre	
	Mean	Percent of A54-1	Mean	Percent of A54-1	Mean	Percent of A54-1
	%	%	Lbs.	%	Lbs.	%
A54-1	16.10	100.0	3.13	100.0	0.5039	100.0
Sel. A54-1 Synthetic	16.76*	104.1	3.29	105.1	0.5514*	109.4
Sel. A54-1 Hi	16.20	100.6	3.28	104.8	0.5314	105.5
Sel. A54-1 Lo	16.54*	102.7	3.04	97.1	0.5028	99.8

* The t test reveals that the odds are greater than 19:1 against the differences between these values and the corresponding values of A54-1 being chance deviations from zero.

Population genetic studies were also conducted in 1958 including A54-1, Selection A54-1 Synthetic, Selection A54-1 Hi, Selection A54-1 Lo, and four other populations two of which were non-segregating populations. These latter two were used to obtain estimates of the environmental variances. Only the findings for the first four populations will be considered in this paper.

The means for percentage sucrose, weight per root, and sugar per root are listed in table 6. Selection A54-1 Synthetic represents an increase over A54-1 of 4.1 percent in percentage sucrose and 5.1 percent in weight per root. The increase in percentage sucrose of 0.66 percent is statistically significant at the 5-percent level. The odds against the difference of 0.16 pounds per root being due to chance are approximately 5:1. However, in 1957 the progeny from the 32 parental plants from which the 10 plants giving rise to Selection A54-1 Synthetic were chosen gave a 7.1 percent increase in weight per root. This increase over A54-1 is significant at the 1-percent level.

Selection A54-1 Hi shows a 0.6 percent increase above A54-1 in percentage sucrose and 4.8 percent increase in weight per root. Neither of these increases is significant at the 5-percent level. However, in the polycross test also conducted in 1958 this material showed an increase of 6.1 percent in weight per root which is statistically significant at the 1-percent level. Considering the data from the two tests there seems to be little reason for doubting that Selection A54-1 Hi represents an increase in weight per root over A54-1 for 1958.

As compared with A54-1, Selection A54-1 Lo shows a significant increase in percentage sucrose and 0.09 pounds decrease in weight per root. However, the t test shows that this decrease in weight per root is readily accounted for by chance fluctuation.

Variances

The obtained and genetic within-plot variances and F values for percentage sucrose for the population genetic studies conducted in 1958 are listed in table 7. The variance of inbred 55-8035 is used as a measure of the environmental variance. The degrees of freedom for each population are 240 and the F value at the 1-percent level is 1.39 and the 5-percent level is 1.26. The genetic variances of all the segregating generations are significantly different from zero. This deduction is justified by the magnitude of the F values in column 5 of table 7. The genetic variances for Selection A54-1 Synthetic and Selection A54-1 Lo are less than the genetic variance of A54-1, the population from which they were derived. The odds are great that these differences are not due to chance fluctuations. It is interesting to note that these populations averaged significantly higher in percentage sucrose than A54-1. Apparently the genetic variability of these populations for percentage sucrose has been reduced compared with the population from which they were selected.

Table 7. Obtained and genetic within-plot variances and F values for percentage sucrose, population genetic studies, 1958.

Population	Variance		F value 2/	
	Obtained	Genetic	A54-1 3/	55-8035
A54-1	2.3283	1.1695		2.01
Sel. A54-1 Synthetic	1.9251	0.7663	1.20-	1.66
Sel. A54-1 Hi	2.8614	1.7026	1.23	2.47
Sel. A54-1 Lo	1.7412	0.5824	1.34-	1.50
50-8035, inbred	1.1588 1/		2.01-	

1/ The obtained variance for 55-8035 is used as an estimate of the environmental variance.

2/ The degrees of freedom for each population are 240 and the F value at the 1% level is 1.39 and the 5% level is 1.26.

3/ The minus sign after the F value indicates that the obtained variance is less than the obtained variance of A54-1 with which it is compared.

The obtained, estimated environmental, and genetic within-plot variances and t values for weight per root are listed in table 8. As shown by the t values under 55-8035, all the genetic variances for the segregating populations are significantly different from zero. An examination of the t values listed under A54-1 shows that of the segregating populations only Selection A54-1 Hi has a genetic variance significantly larger than that of A54-1. The genetic variances of Selection A54-1 Synthetic and Selection A54-1 Lo are not significantly different from the genetic variance of A54-1.

Table 8. Obtained, estimated environmental, and genetic within-plot variances and t values for weight per root; population genetic studies, 1958.

Population	Variance			t values 2/	
	Obtained	Estimated 1/	Genetic	A54-1 3/	55-8035
A54-1	4.3141	0.9484	3.3657		6.722
Sel. A54-1 Synthetic	4.3714	0.9995	3.3719	0.012	6.734
Sel. A54-1 Hi	5.7022	0.9963	4.7059	2.677	9.399
Sel. A54-1 Lo	4.0760	0.9197	3.1563	0.418-	6.304
55-8035, inbred	0.4699			6.722-	

1/ The environmental variances are estimated from data of 55-8035 for the 80 replications (see Powers, Robertson, and Remmenga, 1958 [7]).

2/ The degrees of freedom for t are 474 and the t value for the 1-percent point is 2.588 and for the 5-percent point is 1.966; the standard error of a difference between genetic variances is 0.5007.

3/ The minus sign after the t value indicates that the genetic variance is smaller than the genetic variance of A54-1.

Frequency Distributions

A study of the genetic variances given immediately above indicates that information of interest to the sugarbeet breeder can be obtained by partitioning the frequency distributions into the identifiable numbers and proportions of genetic deviates in the lower and higher classes.

In table 9 are listed the obtained frequency distributions for percentage sucrose and weight per root based on lower, middle, and higher classes partitioned into the identifiable numbers and proportions of genetic deviates. For methods and procedures see Powers, Robertson, and Clark, 1958 [6].

The sugarbeet breeder is interested in the higher classes of the frequency distributions. With the exception of Selection A54-1 Lo,all populations for percentage sucrose have identifiable proportions of genetic deviates in the higher classes of the frequency distributions. Selection A54-1 Lo does not have any identifiable proportion of genetic deviates in the higher classes of the frequency distribution. It is interesting to note that Selection A54-1 Lo (see table 7) had the lowest genetic variance for percentage sucrose and was significantly higher in mean percentage sucrose than was A54-1, the material from which it was selected. Even though the genetic variance of 0.5824 is significantly different from zero the higher classes of the frequency distribution do not show identifiable proportions of genetic deviates.

The mean percentage sucrose for Selection A54-1 Synthetic was also higher than that of A54-1 and the genetic variance was significantly lower. However, the higher classes of the frequency distribution in this case do show genetic deviates and all of them cannot be explained as chance deviates from zero.

Turning to a consideration of weight per root an examination of the frequency distributions in table 9 reveals that genetic deviates occur in the higher classes of all populations. It should be possible by appropriate breeding procedures to further increase weight per root in all of the populations derived from A54-1 and to increase percentage sucrose by further breeding within populations A54-1 Synthetic and Selection A54-1 Hi.

It seems that further information of value might be obtained by calculating from the values in table 9 the identifiable number of individuals genetically superior for both characters.

Table 9. Obtained frequency distributions for percentage sucrose and weight per root based on lower, middle, and higher classes partitioned into the identifiable numbers and proportions of genetic deviates, population genetic studies, 1958.

Population and distribution	Percentage sucrose			Weight per root		
	Classes			Classes		
	Lower	Middle	Higher	Lower	Middle	Higher
A54-1						
Obtained	28	231	61	95	161	64
Calculated	14	261	45	39	255	26
Difference	14	- 30	16	56	- 94	38
Proportion	0.50		0.26	0.59		0.59
Sel. A54-1 Synthetic						
Obtained	23	177	120	90	149	81
Calculated	16	200	104	32	252	36
Difference	7	- 23	16	58	-103	45
Proportion	0.30		0.13	0.64		0.56
Sel. A54-1 Hi						
Obtained	65	191	64	132	101	87
Calculated	43	225	52	70	214	36
Difference	22	- 34	12	62	-113	51
Proportion	0.34		0.19	0.47		0.59
Sel. A54-1 Lo						
Obtained	32	212	76	100	150	70
Calculated	25	214	81	45	255	20
Difference	7	- 2	- 5	55	-105	50
Proportion	0.22			0.55		0.71

In table 10 are listed the obtained number of individuals in 320 over 17.25 percent sucrose and over 4.5 pounds in weight and estimated number of genetic deviates in 10,000 falling into those higher classes having identifiable proportions of genetic deviates. The number of roots obtained in 320 having more than 17.25 percent sucrose and weighing more than 4.5 pounds for Selection A54-1 Synthetic is 14 and the corresponding value for A54-1 is 4. Homogeneity chi square is 5.719 and the odds against these being chance deviates are greater than 49:1. The number of genetic deviates in 10,000 for Selection A54-1 Synthetic is 32, for A54-1 is 19, and for Selection A54-1 Hi is 21. It seems that the chance for further breeding within population Selection A54-1 Synthetic is good. Whether such actually is the case and what breeding methods should be employed are dependent upon further fundamental information concerning these genetically superior individuals listed in column 3 of table 10. Additional study of the individual plant data from the 1957 polycross tests provides some of this information.

Table 10. Obtained number of individuals in 320 over 17.25 percent sucrose and over 4.5 pounds and estimated number of genetic deviates in 10,000 falling in the higher classes having identifiable numbers of genetic deviates, population genetic studies, 1958.

Population	Number obtained in 320 over 17.25 percent sucrose and over 4.5 lbs. weight	Number of genetic deviates in 10,000 1/
A54-1	4 2/	19
Sel. A54-1 Synthetic	14 2/	32
Sel. A54-1 Hi	6	21

1/ The values in this column were calculated from the numbers listed in column 2 of this table and the corresponding proportions listed in columns 4 and 7 of table 9.

2/ Homogeneity chi square is 5.7190 and the odds against these being chance deviations from a common frequency distribution are greater than 49:1.

Heterosis and Genetic Diversity

The data pertain to heterosis and genetic diversity.

Heterosis

The data furnished by the 1957 polycross test pertaining to heterosis will be examined first. It will be recalled that the 1957 polycross tests included the progeny from 32 mother beets selected from 40 small units which had a total of approximately 11,520 plants. The progeny of the 32 mother beets were arranged in order of the magnitude of the means for weight per root and divided into four classes, each composed of the progeny of eight mother beets. Those having the largest means were designated as class 1 and those having the smallest mean as class 4. The means and obtained, estimated, and residual variances are listed in table 11.

Table 11. The class means, obtained, estimated, and residual within-plot variances for weight per root, polycross test, 1957.

Class and A54-1 (check)	Mean	Variance		
		Obtained	Estimated	Residual
1	2.21	1.2688	1.1325	0.1363*
2	2.04	0.9924	0.9936	-0.0012
3	1.95	0.8563	0.9184	-0.0621
4	1.83	0.7500	0.8183	-0.0683
A54-1 (check)	1.88	0.8352	0.8415	-0.0063

* By the t test the odds against this residual variance being a chance deviate from zero are greater than 99:1. The other residual variances are not significantly different from zero at the 5% level.

The only residual variance significantly different from zero is that for class 1. This class is composed of the eight progenies having the highest mean weight per root. Since the estimated within-plot variance is calculated by employing the environmental regression of the variances on their corresponding means, the magnitude of the means has been taken into account. Hence this residual variance can be attributed primarily to genetic causes and is that portion of the genetic variance in excess of the average genetic variance of the entire experiment, including A54-1. The fact that the average residual variance for the selections of 0.0012 and that for A54-1 of -0.0063 is not significantly different from zero furnishes rather conclusive evidence that the difference between the within-plot variance of the selections and the within-plot variance of A54-1 is due to the differences in the magnitude of the means. Such being the case, considerable confidence can be placed in the finding that the progenies grouped in class 1 have larger genetic variances on the average than the progenies of the balance of the selections and a larger genetic variance than the A54-1 parent from which they were derived.

When interpreting these results, it is well to keep in mind that the polycross test as applied in these studies measures the general combining ability of the 32 mother beets grown in the isolated seed plot. Such being the case, it seems logical that the eight mother beets whose progeny composed class 1 were, on an average, genetically superior to the average of the plants of A54-1 because at least some of them exhibited heterosis for weight per root. Also, to a great extent their progeny must have resulted from cross-fertilization. Another logical deduction is that at least some of these original eight mother beets should be genetically superior breeding material, especially if the breeding program is designed to take advantage of combining ability. These findings are for yield of root as measured by weight per root and weight of roots per plot. It seems probable that further consideration of some of the progenies of the selections grouped in class 1 will provide additional information on heterosis.

The data from the two progenies having the largest residual variances for weight per root are listed in table 12. The estimated within-plot variances for percentage sucrose are those for A54-1 (Check) for the group in which the selection was grown. As before, the estimated within-plot variances for weight per root were calculated by employing regression of the variances on mean weight per root. For percentage sucrose, in both cases, the variances are larger than those for A54-1. However, taken individually the differences are not significant at the 5-percent level. The mean percent sucrose for 4W-34 is significantly larger than the mean of A54-1 grown in the same group. For weight per root selections 11W-45 and 4W-34 have greater weight per root and larger variances than does A54-1. The odds are greater than 99:1 against the differences being due to chance. It is evident from these results that the genetic variability of 11W-45 and 4W-34 is greater than that for A54-1, as regards weight per root, and at least equal to that of A54-1 for percentage sucrose. The progeny of 4W-34 represent an advance in both weight per root and percentage sucrose, as shown by a comparison of the means (see table 12).

Table 12. The means and obtained, estimated, and residual within-plot variances for percentage sucrose and weight per root, selections 11W-45 and 4W-34, polycross test, 1957.

Character, selection, and check	Mean	Variance		
		Obtained	Estimated	Residual
Sucrose, %				
11W-45	15.1	2.0986	2.0719	0.0267
A54-1	15.2	2.0719		
4W-34	16.0	2.7475	2.6021	0.1454
A54-1	15.5	2.6021		
Weight, lbs.				
11W-45	2.24 2/	1.4213	1.1615	0.2598 1/
A54-1	1.96 2/	0.8962	0.9168	-0.0206
4W-34	2.18 3/	1.4171	1.1075	0.3096 1/
A54-1	1.83 3/	0.7176	0.8044	-0.0868

1/ By the t test the odds against these residual variances being chance deviates from zero are greater than 99:1.

2/ By the t test the odds against the differences between these values being chance deviates from zero are greater than 99:1.

3/ By the t test the odds against the differences between these values being chance deviates from zero are greater than 99:1.

From the above study it may be concluded that the results are those expected if the individuals indicated to be genetically superior by partitioning and isolated by selection from small units and progeny testing are genetically superior because they exhibit heterosis for weight per root. Indications are that the same is true for those individuals having greater percentage sucrose. If such proves to be the case, these findings have practical applications in breeding sugarbeets. This is particularly true as regards methods of breeding to be used and procedures to be followed in applying these methods.

Genetic Diversity

The data for Selection A54-1 Synthetic and the 1959 polycross tests of the mother line selections from the progeny of the 32 mother beets grown in the 1957 polycross test will be partitioned to determine genetic diversity.

It was shown in a discussion of the data in table 12 that the genetic variances for percentage sucrose of the progeny of 11W-45 and 4W-34 are at least equal to the genetic variance of A54-1, the material from which both were derived. The genetic variances for weight per root of the progenies of these two mother beets were found to be greater than the genetic variance of A54-1. These two mother beets had been grown in a polycross isolation plot with 30 other mother beets all of which had been derived from A54-1. Hence, barring unequal mutation frequencies the genetic diversity of the progenies from mother beets 11W-45 and 4W-34 could not have been greater than the material (A54-1) from which they were derived. It seems highly probable that they are not as diverse genetically even though the genetic variances indicate that they might be more diverse as regards weight per root. Mother beets 11W-45 and 4W-34 were two of the 10 mother beets grown in an isolation plot to produce Selection A54-1 Synthetic. It seems as though a study of the detailed frequency distributions of A54-1 and Selection A54-1 Synthetic grown in the 1958 population genetic studies might yield information concerning the comparative genetic diversity of these two populations. It was decided to partition the obtained frequency distribution for percentage sucrose of Selection A54-1 Synthetic on the basis of A54-1.

The detailed frequency distribution and the partition are shown in table 13. The third row heading designated "difference" shows the partition. The values up to and including class 16.50 percent are all negative whereas all values for classes above 16.50 percent are positive. These are the results expected if as was indicated by a comparison of the means (see table 5), the plants of Selection A54-1 Synthetic represent an average increase in percentage sucrose over the material from which they were derived, namely A54-1. However, the increase (39 compared with 12) in the number of individuals, in row heading "difference", in class 18.00 as compared with class 17.25 indicates that Selection A54-1 Synthetic is

composed of at least two major subgroups representing different genotypes. If such is correct, further breeding within Selection A54-1 Synthetic should result in an increase in percentage sucrose. The partition of the frequency distribution of Selection A54-1 Synthetic on the basis of A54-1 shows what genetic changes have been brought about by the breeding methods employed in this case; namely, selection from small units followed by the polycross method of breeding. Further, it shows that the breeding procedures practiced may have resulted in a bimodal frequency distribution. The relation between this and genetic diversity will be pointed out later after considering the partitioned frequency distributions for weight of root.

The detailed frequency distributions and the partition for weight of root are shown in table 14. The partition shows that as compared with A54-1 frequency distribution the frequency distribution of Selection A54-1 Synthetic has fewer individuals in the lower classes, more in the middle classes and higher classes with the exception of the 4.5 pound class. Homogeneity chi square based on the sets shown by the vertical lines is 9.314, whereas the chi square value at the 5-percent level is 9.488. The degrees of freedom are 4. It should be noted that for the first four lower classes of the frequency distribution the differences between Selection A54-1 Synthetic and A54-1 are not pronounced. Selection from small units followed by the polycross method of breeding seems to have separated the population into three distinct groups. This has resulted in a trimodal frequency distribution which is clearly brought out by partitioning the frequency distribution of Selection A54-1 Synthetic on the basis of A54-1, the material from which it was derived.

Table 13. The obtained frequency distribution for percentage sucrose of Selection A54-1 Synthetic partitioned on the basis of the obtained frequency distribution of A54-1, population genetic studies, 1958.

Population and difference	Upper limit of class, percent									
	12.75	13.50	14.25	15.00	15.75	16.50	17.25	18.00	18.75	19.50 and over
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Sel. A54-1 Synthetic		2	4	17	33	81	63	79	28	13
A54-1	4	6	18	35	60	85	51	40	14	7
Difference	- 4	- 4	-14	-18	-27	- 4	12	39	14	6

Table 14. The obtained frequency distribution for weight per root of Selection A54-1 Synthetic partitioned on the basis of the obtained frequency distribution of A54-1, population genetic studies, 1958.

Population and difference	Upper limit of class, pounds													
	0 to 0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0 and over
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Sel. A54-1 Synthetic	14	17	24	35	17	37	45	31	19	27	14	11	10	19
A54-1	15	17	25	38	33	39	32	30	27	17	10	9	11	17
Difference	- 1	0	- 1	- 3	-16	- 2	13	1	- 8	10	4	2	- 1	2

As shown above by the homogeneity chi square values, these findings are not too well established statistically. Further research is desirable. If these findings are confirmed by further research they have important implications to breeding sugarbeets. For example, as was shown, the genetic variances for weight per root, taking into account the magnitude of the means for Selection A54-1 Synthetic and A54-1, are not materially different. However, the partitioning given in table 14 indicates that the frequency distributions might be materially different; that is, certain genotypes having average combining ability and certain other genotypes having higher combining ability have been increased in population Selection A54-1 Synthetic. This would mean that other genotypes with different combining ability have been eliminated. Hence the genetic diversity of Selection A54-1 Synthetic has been reduced even though this is not shown in a decrease in the genetic variance. This failure of a decrease in the genetic variance even though there has been a decrease in genetic diversity is probably due to the trimodal nature of the frequency distribution. In other words, the breeding procedures followed have been successful in concentrating genes for higher combining ability and mediocre combining ability but have not materially reduced the number of individuals having poor combining ability. The reduction has been in the classes having from poor to mediocre combining ability and in the class (4.5) having from mediocre to superior combining ability. It must be remembered that Selection A54-1 Synthetic resulted from growing in an isolation plot the asexually propagated 10 mother beets whose progeny showed superiority in a polycross test. If some of these 10 mother beets are genetically similar in the genes they carry for high combining ability, the progenies from cross-fertilizations involving them would tend to have values below the mean of the material from which they were derived and the progenies from others not quite so similar genetically for high combining ability would tend to approach the mean of the population from which they were derived. Finally, the progenies from still others carrying quite genetically diverse genotypes would tend to again produce individuals showing high weight per root, resulting in the bimodal and trimodal nature of the frequency distributions of Selection A54-1 Synthetic as shown by the partitioning given in tables 13 and 14. It seems that the genetic diversity of Selection A54-1 Synthetic has been materially reduced, even though for weight per root this has not been reflected in the magnitude of the genetic variance. Further selection in this material could result in a further reduction in genetic diversity that would be reflected in a decided increase in the poor combining group and a decrease in the number of individuals in the high combining group. Some data from the 1959 polycross test have a bearing on this problem.

It will be recalled that in the 1957 polycross test the progeny from 32 mother beets were grown. The number of replications was 5, the number of groups was 3, and the number of plants saved per replication was 20, making a total of 100 plants for each of the 32 progenies and a grand total of 3200 plants. Selections among this total of 3200 beets were made, first

placing the emphasis on percentage sucrose and secondly on weight per root. After the data from the polycross test were analysed the number of mother beets was reduced to 55 on the basis of the performance of the progeny of the mother beets from which they were derived compared with the performance of A54-1 in the group in which they were grown. Since the final selection was based upon the performance of the progenies in which they occur this has been termed mother line breeding within the polycross test. These 55 mother beets were grown in an isolation plot and seed harvested on an individual plant basis. Fifty of these progenies were grown in the 1959 polycross combining ability tests. Hence the 50 beets represent a mother line within the polycross test of the progenies of the 32 mother beets. It will be recalled (see table 5) that the progenies of these 32 mother beets were equal to A54-1 in percentage sucrose and showed an increased weight per plot of 7.1 percent which was statistically significant at the 1-percent level.

The means for percentage sucrose and weight per root for the mother line selections in the polycross test and A54-1 are listed in table 15. In making the mother line selections among the progenies of the 32 mother beets, emphasis was first placed on percentage sucrose and secondly on weight per root. The 50 progenies of the mother line selections average significantly higher in percentage sucrose than did A54-1, the material from which they were originally derived. There was no material difference in weight per root.

It is desirable to know whether there are genetic differences among the 50 progenies. The data are summarized in table 16. The genetic variances for both percentage sucrose and weight per root are significantly different from zero. A study of the frequency distributions of the means of these 50 progenies will be made to determine what bearing they have on genetic diversity.

Table 15. The means for percentage sucrose and weight per root for the mother line selections and A54-1, progeny tests, 1959.

Population	Percentage sucrose	Weight per root
	%	Lbs.
Mother line selection	13.31 1/	1.83
A54-1	12.71 1/	1.81

1/ The odds are greater than 99:1 against the difference between these values being a chance deviation from zero.

Table 16. For percentage sucrose and weight per root total, environmental, and genetic within replication and within group variances due to differences between means of progenies of 50 selections, progeny tests, 1959.

Character	Variance		
	Total 2/	Environmental 2/	Genetic
Percentage sucrose	0.7597	0.4114	0.3484 1/
Weight per root	0.1042	0.0606	0.0436 1/

1/ The odds are greater than 99:1 against these values being chance deviations from zero.

2/ The degrees of freedom for total are 45 and for environmental are 205.

The obtained and calculated frequency distributions for mean percentage sucrose are listed in table 17. The means have been adjusted to eliminate differences between group means. The data are grouped into 3 classes as shown by the vertical lines in table 17. This provides at least 10 individuals in each class of the theoretical frequency distribution used in calculating homogeneity chi square. Homogeneity chi square shows that the difference between the two frequency distributions is readily accounted for by chance. This is true even though genetic variability between means of progenies for percentage sucrose has been shown to exist. Even though it cannot be established as statistically significant, there is a tendency of the data to fall into 3 sets as shown by the vertical lines in table 17. This tendency is in agreement with the data of table 13, indicating that for percentage sucrose, selection followed by the polycross method of breeding has resulted in the frequency distribution showing more than one mode.

Table 17. The obtained and calculated frequency distributions and differences for percentage sucrose, progeny means adjusted for groups, progeny test, 1959.

Frequency distribution	Upper limit of class, percent								
	12.50	12.75	13.00	13.25	13.50	13.75	14.00	14.25	14.50
	No.	No.	No.	No.	No.	No.	No.	No.	No.
Obtained	3	4	7	7	10	13	3	2	1
Calculated 1/	2	4	7	10	11	8	5	2	1
Difference	1	0	0	- 3	- 1	5	-2	0	0

1/ The calculated frequency distributions are based on the standard errors calculated from the 10 means of A54-1, the means being adjusted to eliminate variability due to groups.

The obtained and calculated frequency distributions for weight per root of the progeny means adjusted to eliminate the variability due to groups are listed in table 18. The data are grouped into 3 classes as shown by the vertical lines. This provides at least 9 individuals in each class of the theoretical frequency distribution used in calculating homogeneity chi square. Homogeneity chi square is 30.4716 and the odds are greater than 99:1 against these two frequency distributions being chance deviations from a common frequency distribution. It is clear that on the basis of combining ability the obtained frequency distribution is bimodal. This is clearly brought out by partitioning the obtained frequency distribution to show the number of identifiable genetic deviates in the lower and higher classes. In fact, the mean (1.83) falls into the class of lowest frequency; namely, the class having an upper class limit of 1.90 pounds. This shows that the obtained frequency distribution is composed of at least two subgroups, the first having a mean of 1.68 and the second having a mean of 2.00. The number of individuals in the first group is 27 and in the second group is 23. The first group is composed of the progenies having mean weights per root ranging from 1.31 to 1.85 pounds, and the second group is composed of progenies ranging from 1.86 pounds to 2.20 pounds. The mean weight per root of A54-1 is 1.81 pounds.

Table 18. The obtained and calculated frequency distributions and differences for weight per root, progeny means adjusted for groups, progeny test, 1959.

Frequency distribution	Upper limit of class, pounds								
	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20
	No.	No.	No.	No.	No.	No.	No.	No.	No.
Obtained	1	0	5	10	9	4	9	9	3
Calculated 1/				2	15	25	8		
Difference	1	0	5	8	- 6	-21	1	9	3

1/ The calculated frequency distributions are based on the standard errors calculated from the 10 means of A54-1, the means being adjusted to eliminate variability due to groups.

The changes that have taken place during the breeding period are of fundamental importance. As compared with the frequency distribution of A54-1 by partitioning, the frequency distribution of Selection A54-1 Synthetic is trimodal. The highest mode is 160 percent of the material from which it was selected [(5.00 ÷ 3.13)100]. This is an increase of 60 percent providing a population composed entirely of plants having the genotype or genotypes of this subgroup can be developed. The highest classes of the frequency distribution of the means of the polycross progeny resulting from mother line selection within the 1957 polycross test have a mean of 2.00. The mean of A54-1 is 1.81. This is only an increase in weight per root of 10.5 percent.

The total within-plot and within-group variances due to differences between individual plants in progenies of the 50 selections and between individuals of A54-1 are listed in table 19. The data show that compared with A54-1 the variance for percentage sucrose was reduced. This was not true for weight per root.

Table 19. For percentage sucrose and weight per root total within plot and within group variances due to differences between individuals in progenies of the 50 selections and between individuals of A54-1, progeny test, 1959.

Population	Degrees of freedom	Total variance: Percentage sucrose	Total variance: Weight per root
Mother line selection	3500	1.5247 1/	0.9479 2/
A54-1	700	2.2007 1/	0.8939 2/

1/ The odds against the difference between these two variances being chance deviations from zero are greater than 99:1.

2/ The odds against the difference between these two variances being chance deviations from zero are less than 19:1.

The results from partitioning the frequency distributions in tables 13, 14, 17, and 18 and studying the total variances in table 19 and the genetic variances in previous tables merit further consideration. Selection from small units followed by the polycross method of breeding resulted in an increase in both percentage sucrose and weight per root. Genetic diversity is reduced for both characters, as shown by a lower genetic variance for percentage sucrose and the trimodal (table 14) and bimodal (table 18) frequency distributions for weight per root. As might be expected from these results, a further reduction in genetic diversity is shown by the progeny test of the mother line selections conducted in 1959. This decrease in genetic diversity is accompanied by a decline in weight per root to such an extent that, on an average, the mother line selections no longer possess an advantage in weight per root over A54-1. However, the advantage in percentage sucrose is retained. This is the result expected if comparatively few genes governing the production of high sucrose are segregating in this material. Such being the case it is possible to fix in the homozygous condition some of the genes for high sucrose production. Then the reduction obtained in the genetic variance by the methods of breeding employed is expected.

Even though the genetic variances for weight of root are not reduced as compared with A54-1, there is a reduction in genetic diversity. This is shown by the trimodal nature of the frequency distribution, table 14, and the bimodal nature of the frequency distribution, table 18. This conclusion is based upon the interpretation that the mother beets whose progeny fell into the lower classes of the frequency distribution carried at least some similar genes for high combining ability and hence lacked genetic diversity; whereas those falling into the higher classes of the frequency distribution carried genes for high combining ability that are diverse from the genes for high combining ability of the majority of the mother beets pollinating them. As a consequence their progeny fell into the higher classes of the frequency distribution. If such is the true interpretation of the results, further breeding for general combining ability by selection from small units followed by mother line selection in this material would result in further reduction in weight per root of the synthetic variety produced. This is true because a further reduction in genetic diversity would increase the number of progeny resulting from crossing between heterozygotes which in themselves showed heterosis but had similar genetic constitution. Their progeny in a synthetic variety would tend toward the yield of an F_2 population and would stabilize at a level depending upon the genetic diversity of the mother beets making up the synthetic variety.

Whether the above interpretation of the data is correct is subject to experimental proof or disproof. The interpretation advanced is based on the contention that the breeding program was successful in concentrating high general combining ability genes in the populations bred. If such is the case, when crossed with non-related heterozygous testers the progeny should exhibit higher weight per root than the progeny of A54-1 crossed to the same testers. Such research is under way at Fort Collins.

DISCUSSION

A study of the frequency distributions by the partitioning method has indicated certain fundamentals which, if corroborated by further research, will have a decided bearing on methods of breeding sugarbeets. These will be discussed in respect to their application.

There was sufficient genetic diversity in A54-1 so that selection from small units followed by the polycross method of breeding isolated individuals genetically superior for both percentage sucrose and yield of roots. Ten of the first isolates had sufficient genetic diversity to give high yields when grown as a synthetic variety; that is, the synthetic variety showed higher percentage sucrose and higher weight per root than did A54-1, the material from which it was produced. As compared with A54-1, there was a reduction in the genetic variance for percentage sucrose but not a reduction in the genetic variance for weight per root. The progeny from mother beets resulting from mother line selection in the polycross tests, on the average maintained the advantage of the first productions in percentage sucrose, but the root yield was not higher than that of A54-1. The partitioning method of analyzing the progenies and populations resulting from the breeding program indicated, as regards weight per root, that there had been a reduction in genetic diversity of the mother beets grown in the second polycross isolation plot. However, the partitioning showed that, even though the average genetic diversity of the mother beets grown in the polycross isolation plot was not sufficient to give an increased yield of roots over A54-1, some had sufficient genetic diversity to give higher yields of roots than A54-1.

This rather clearly points out that, if selection from small units followed by the mother line method of breeding is to be successful in producing increased yields of roots, it will be necessary to use some method of determining which superior genetic isolates (mother beets) have good combining ability when crossed with each other. In other words, the procedures will be similar to that used by corn breeders to determine which F_1 hybrids combine well to produce superior double crosses. However, the sugarbeet breeders following these procedures will not have available the inbred lines but only the heterozygous mother beets for testing combining ability. The asexually propagated mother beets proven to be good combiners then can be used directly to produce the synthetic variety to produce inbred lines for use in producing hybrids or for producing a synthetic variety.

Also, those breeders making recurrent selections in connection with the polycross method of breeding may find it necessary to conduct specific combining ability studies and to use only those asexually propagated mother beets, to produce the synthetic variety, that combine well in all possible combinations.

In case of the recurrent selection method of breeding, selection from small units can be used to isolate genetically superior individuals and the combining ability of these tested by crossing with an exceptional inbred line or with some exceptional variety or strain. The partitioning of the breeding material from each cycle would show when further recurrent selection would no longer be effective. The same should apply to selection from small units followed by the reciprocal recurrent selection method of breeding, with the exception that it would be necessary to apply the partitioning to each of the two sources for each cycle to determine the desirability of continuing further cycles of breeding.

Any of the three methods of breeding (selection from small units followed by polycross, by recurrent selection, or by reciprocal recurrent selection) should provide excellent material for starting an inbreeding program. The material used from the polycross would be the asexual propagations from the mother beets that had proven to have exceptional combining ability with each other. The material used from the recurrent selection program would be the lines that had proven to be superior combiners with the recurrent parent. Finally, the material from which inbreeding would be started in regards to reciprocal recurrent selection would be both sources of any cycle, but probably the most desirable would be that from the last cycle.

SUMMARY

1. The partitioning method of genetic analysis in population genetic studies with A54-1 showed that, comparatively, A54-1 is highly heterozygous and heterogeneous.

2. Researches on methods of breeding sugarbeets were started with A54-1 in 1956. Data are available on selection from small units followed by the polycross method of breeding and mother line selection within a polycross test.

3. Partitioning the frequency distributions of the breeding material on the basis of the environmental variances and in other cases on the basis of A54-1 provided information of fundamental importance to methods of breeding sugarbeets. Also, it proved effective in evaluating the breeding material and the progress of the breeding program.

4. Applying the partitioning method of genetic analysis to the frequency distributions of Selection A54-1 Synthetic (grown in population genetic studies) and to the progeny means of the mother line selections made from the 1957 polycross test (grown in a polycross test in 1959) showed that for weight per root the genetic variances are not less than those of A54-1 but the genetic diversity is less.

5. The decrease in genetic diversity of the mother line selections (as shown by partitioning the frequency distributions of the progeny means) is accompanied by a decrease in weight per root to such an extent that the mean for weight per root of the progenies of the mother line selections is not greater than that of A54-1. The weights per root are 1.83 and 1.81 pounds respectively.

6. The application of these findings to the different methods of breeding sugarbeets is discussed under the section entitled "DISCUSSION".

7. It should be kept in mind that the data reported herein are not extensive and hence further research is necessary. Also that the interpretations placed on the data are subject to proof or disproof by further research and it is imperative that this research be conducted before drawing final conclusions.

LITERATURE CITED

1. Comstock, R. E., Robinson, H. F., and Harvey, P. H. 1949. A breeding procedure designed to make maximum use of both general and specific combining ability. Agron. Jour. 41:360-367.

2. East, E. M. and Hayes, H. K. 1912. Heterozygosis in evolution and in plant breeding. U. S. Dept. Agr., Bur. Plant Ind. Bull. 243.

3. Hull, Fred H. 1945. Recurrent selection for specific combining ability in corn. Jour. Amer. Soc. Agron. 37:134-145.

4. Powers, LeRoy. 1945. Strawberry breeding studies involving crosses between the cultivated varieties (X *Fragaria ananassa*) and the native Rocky Mountain strawberry (*F. ovalis*). Jour. Agri. Res. 70:95-122.

5. Powers, LeRoy. 1957. Identification of genetically-superior individuals and the prediction of genetic gains in sugar beet breeding programs. Amer. Soc. Sugar Beet Tech. IX(5):408-432.

6. Powers, LeRoy, Robertson, D. W., and Clark, A. G. 1958. Estimation by the partitioning method of the numbers and proportions of genetic deviates in certain classes of frequency distributions. Jour. Amer. Soc. Sugar Beet Tech. IX(8):677-696.

7. Powers, LeRoy, Robertson, D. W., and Remmenga, E. E. 1958. Estimation of the environmental variances and testing reliability of residual variances for weight per root in sugar beets. Jour. Amer. Soc. Sugar Beet Tech. IX(8):697-708.

8. Powers, LeRoy, Robertson, D. W., Whitney, Robert S., and Schmehl, Willard R. 1958. Population genetic studies with sugar beets (*Beta vulgaris* L.) at different levels of soil fertility. Jour. Amer. Soc. Sugar Beet Tech. IX(8):637-676.

9. Shull, G. H. 1909. A pure-line method of corn breeding. Amer. Breeders' Assoc. Rpt. 5:51-59.

10. Tysdal, H. M., Kiesselbach, T. A., and Westover, H. L. 1942. Alfalfa Breeding. U. Nebr. Agric. Res. Bul. 124, 46 pp.

11. Vilmorin, Louis de. 1856. Note sur la création d'une nouvelle race de betterave à sucre; considérations sur l'Hérédite dans les végétaux. Compt. Rend. Acad. Sci. (Paris) 43: 871-874. (Also in his Notices sur l'Amélioration des Plantes par le Semis et Considérations sur l'Hérédite dans les Végétaux. Nouv. éd., p. 25-29. Paris. 1886.)

[illegible] Hepburn [illegible] Bulletin [illegible] populations [illegible]

[illegible] E. [illegible] 1912. [illegible] Jour. [illegible]

Bull, Fred [illegible] 1955. [illegible] ability [illegible] Jour. [illegible]

Ramsey, LeRoy. 1954. [illegible] Rocky [illegible] Mountain Sta. [illegible]

[illegible] LeRoy. [illegible] prediction of [illegible] Soc. Sugar Beet [illegible] (5) [illegible]

[illegible] LeRoy. Robertson [illegible] An evaluation [illegible] Soc. Sugar Beet Tech. IX(8) [illegible]

[illegible] LeRoy, [illegible] environmental [illegible] vertical [illegible] for weight per root [illegible] 9:697-705.

Powers, LeRoy. Robertson, [illegible] Gilbert E. 1957. Population [illegible] IX(8):631-676.

[illegible] B. 1959. [illegible] 5:51-59.

[illegible] Kavanaugh, [illegible] Amer. [illegible]

[illegible] Hughes [illegible] Amer. Soc. [illegible]

SELECTION AND POPULATION GENETICS STUDY IN A BROAD-BASE MONOGERM POPULATION

This experiment is the first portion of an extended study to obtain fundamental information on methods of breeding sugarbeets. The experiment is designed as a selection study and a population genetics study of a broad-base monogerm population. The characters of interest are weight per root and percentage sucrose.

MATERIALS AND METHODS

The experimental data were collected in 1959. The design of the experiment is essentially as outlined by Powers [5] for making selections from small units. Forty units or replications were used. Included in each unit were ten rows of a broad-base monogerm population, from which selections were made and one row each of an inbred and an F_1 hybrid. There were about 24 plants per row, making a total of 11,520 plants (24 x 12 x 40) in the experiment. Of this total, 9,600 were plants of the broad-base monogerm population and 1,920 were of the inbred and F_1 populations.

The broad-base monogerm population was developed at this station in 1956 in cooperation with the American Crystal Sugar Company. It was developed using SLC 15, a heterogeneous mendelian self-sterile monogerm line, as the female parent with the following heterogeneous multigerm lines and varieties used as pollinators:

1. GW-359-52R, high root weight and high sucrose commercial variety.
2. AC No. 2, high root weight and high sucrose commercial variety.
3. Midwest 391, high root weight and high sucrose commercial variety.
4. US 201, highly leaf spot resistant line.
5. SL 028, highly curly top resistant line.
6. US 400, root rot resistant line.
7. Janasz, extremely high sucrose European variety.

The proportion of pollen contributed by each pollinating line was undetermined. The first open-pollinated generation was used as an increase stock. About 10,000 stecklings from the seed of the first open-pollinated generation were grown and rogued prior to anthesis for the monogerm character. About 470 monogerm selections remained to interpollinate, giving rise to the second generation open-pollinated seed which was used in this experiment. Remnant seed of both the first and second open-pollinated generations remain to be used to measure any genetic shift in the population.

The inbred and the F_1 hybrid were included in the experiment to obtain a measure of the environmental variability and to provide a means of testing the reliability of methods.

Regular spacings of 22 inches between rows and 10 inches between plants within the row were used. Stands were good.

In the harvest eight random roots were taken from each row of the non-segregating populations. Eight random roots were taken from two random rows of the selection material within each unit. These 1,280 roots were analysed individually for weight per root and percentage sucrose. From the remaining 224 plants of the segregating population in each unit the twenty largest roots were visually selected. These 800 roots were analysed individually. After analysis five roots were selected from each unit on the basis of percentage sucrose. Thus the first selection was for weight of root and the second selection was for percentage sucrose.

EXPERIMENTAL RESULTS

In calculating the probability and odds that the 200 selected roots were better than the mean of the unit from which they were selected, it was found that 95 had odds greater than 100:1 of being superior for percentage sucrose. For weight per root there were 92 with odds greater than 100:1 of being superior. Considering both characters simultaneously, there were 47 with odds greater than 60:1 that they are truly superior to the material from which they were selected. These 47 roots were placed in a polycross plot in the summer of 1960 and will be compared in a polycross test in the summer of 1961. Asexual cuttings were taken from each of these roots in 1960.

The next portion of this experiment is essentially a population genetics study of the three populations involved.

Percentage Sucrose

The analysis of variance for percentage sucrose shows that the inbred and F_1 populations are different and that the unit by population interaction is significant. The data are not shown, as the procedures are standard for such an analysis. The within-plot variances of the inbred and F_1 were calculated, and from these variances a standard analysis of variance of within-plot variances was made. This analysis did not show differences between units or populations, even though in table 20 both the total within-plot variance and total variance are higher for the inbred than for the F_1. However, when these populations were treated in separate analyses of variance, units were significantly different in

both populations. Also in testing for a difference between variances due to units in each analysis, the variances due to units are significantly different at the five-percent level with the inbred having the highest variance. The residual variances for the two populations are not different. Hence, within-plot variance is not contributing greatly to the difference noted between total variances in table 20. Units are varying more in the inbred than in the F_1 population. Most of the difference between the total variances of the inbred and the F_1 is due to a unit by inbred interaction.

To further determine the value of the inbred and F_1 as estimates of the environmental variability, frequency distributions were tabulated. Calculated frequency distributions were then developed according to Powers [3], each calculated distribution being based on the mean and standard error of that particular population. The goodness of fit chi square probability values testing whether the population frequency distributions follow the normal probability integral were between 0.50 and 0.25 for the inbred and between 0.10 and 0.05 for the F_1. Hence, individuals in both populations were not deviating from the population means in any manner other than that expected by chance. In considering all these analyses of the non-segregating populations it appears that either, or both, of these populations furnish a satisfactory estimate of the environmental variability. For percentage sucrose, data from the F_1 hybrid are used to estimate the environmental variance and those from the inbred give an empirical test as to reliability of the methods. In analyzing the segregating monogerm population, units and samples were not shown to be different. From a study of the calculated frequency distribution of the monogerm population based on its own mean and standard error, it is evident that the distribution is not normal. There were individuals in this population which deviated from the mean of the population further than would be expected by chance alone. The goodness of fit chi square probability value that these deviations could be due to chance alone is less than 0.01. Individuals in the extreme classes of the frequency distribution contributed most to the large chi square value. These deviating individuals are probably in the extreme classes because of their genotype. To conserve space these frequency distributions are not shown.

This population can therefore be partitioned, using methods of Powers, et al., [6] to determine the identifiable proportion of genetic deviates. It further allows the prediction of genetic gains possible in the population (see Powers [5]).

In table 20 are listed the total genetic variances with their standard errors. As stated above, the F_1 is used to estimate the environmental variance. Therefore, no estimate is possible for the F_1 population. The genetic variance of the inbred is not significantly different from zero as might be expected.

Table 20. Means, total within-plot variances, total variances, and genetic variances with their standard errors; percentage sucrose.

Population	Mean	Variance: Total within plot	Variance: Total	Variance: Genetic
Inbred (34)	11.74	1.4406±0.1289	2.1975±0.1740	0.2145±0.2802
F_1 (52-430 X 52-407)	12.92	1.2261±0.2488	1.5646±0.1239	---- ----
SLC 15 BB_2 (Monogerm)	11.51	4.5256±0.3375	5.3357±0.2985	3.2995±0.4193

Next, the calculated frequency distribution of the segregating population was computed based on its mean and the estimated environmental standard error. The obtained and calculated frequency distributions are listed in table 21. The segregating population has fewer individuals in the center classes and more in the end classes than expected on the basis of chance fluctuations. In all the classes from 0% to 9.75% sucrose there are more individuals obtained than expected, from 10.50% through 12.75% there are less than expected, and from 13.50% upward there are more obtained than expected. The homogeneity chi square probability value testing whether the population frequency distribution follows the normal probability integral based on the estimated environmental standard error is less than 0.01 for the monogerm population.

If the frequency distribution of the segregating population in table 21 is grouped into three classes according to where the difference changes from plus to minus, a homogeneity chi square test gives a P value of less than 0.01 that the deviation from expected is due to chance.

In the monogerm population in table 21 there are six individuals obtained in the class "over 15.75" but none occurred in the calculated frequency distribution. Hence these six individuals are considered the identified-genetically-superior individuals. Then using this percentage of superior individuals, using methods outlined by Powers [5], it is possible to predict genetic gains. The predicted gain is shown in table 22. The mean predicted from the identified-genetically-superior individuals is 12.81 percent as compared to the obtained mean of the population of 11.51 percent. As Powers [5] states, this is probably a conservative estimate because many of the genetically superior individuals fell into lower classes by chance and were therefore not identifiable. Table 22 further shows that there is no predictable gain for the inbred population.

Table 21. Obtained and calculated frequency (based on the environmental standard error) distributions in numbers and their differences for the monogerm population (the F_1 is used as the estimate of the environmental standard error); percentage sucrose.

Population and distribution	0 to 6.00	6.75	7.50	8.25	9.00	9.75	10.50	11.25	12.00	12.75	13.50	14.25	15.00	15.75	over 15.75
Monogerm SLC 15 BB_2															
Obtained	20	12	7	16	29	46	44	83	88	95	92	55	34	13	6
Calculated	0	0	0	3	11	37	83	133	150	120	67	27	7	2	0
Difference	20	12	7	13	18	9	-39	-50	-62	-25	25	28	27	11	6

Table 22. Percentage of identified-genetically-superior individuals and estimated means of the frequency distributions in which these individuals would occur; percentage sucrose.

Population	Value of z for p = 0.001	Value of z used	Superior individuals	Value of x	Mean Obtained	Mean Predicted from superior individuals
Inbred 34	15.455	15.75	0.0	----	11.74	-----
F_1 52-430 X 52-407	16.64	17.25	0.0	----	12.92	-----
SLC 15 BB_2	15.225	15.75	0.94%	2.35	11.51	12.81

Weight Per Root

Analyses of variance for the inbred and F_1 populations for weight per root reveal that populations and units are different and that variance due to units is significantly higher in the F_1 than in the inbred. This is contrary to the result from a study of percentage sucrose, as the variance due to units was higher in the inbred population. Total within-plot variances of the inbred and F_1 were not different. Thus, after taking into consideration the relation of the means and the variances, most of the difference in total variance for the inbred and F_1 is contributed by variation between units in the F_1 population. In a regression analysis of the means and the variances in the non-segregating population, 96.9% of the variance was accounted for by regression.

In the analysis of the monogerm population, no significant differences could be shown to exist between samples or between units.

The calculated frequency distributions, each based on its respective mean and standard error, were computed. Goodness of fit chi squares calculated from the obtained and calculated frequency distributions of the inbred population showed that the distributions followed the normal probability integral satisfactorily. The same calculation for the F_1 population shows that the frequency distribution is normal only in the upper portion. The monogerm frequency distribution did not follow the normal probability integral as shown by a chi square P value of less than 0.01. As in percentage sucrose, the end classes of the distribution contributed most to the large chi square value.

The calculated frequency distributions based on the estimated environmental standard error are shown in table 23. The calculations are made in essentially the same manner as those for percentage sucrose except that regression is used to estimate the environmental variances of the monogerm population (see Powers [2]). As in percentage sucrose, the computation of the calculated frequency distribution, by use of Pearson's tables [1], is based on the actual mean of the population and the estimated environmental standard error.

Table 23. Obtained and calculated frequency distributions (based on the estimated environmental standard error) in numbers and their differences for all populations; weight of root.

Population and distribution	Upper limit of the class																				Total number of plants
	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.60	3.80	over 3.80	
Inbred																					
Obtained	3	19	51	53	67	59	33	25	6	3	0	0	1								320
Calculated	7	16	36	59	71	62	40	20	7	2	0	0	0								320
Difference	-4	3	15	-6	-4	-3	-7	5	-1	1			1								
F_1																					
Obtained	0	5	12	19	23	20	36	29	29	29	25	14	12	18	13	8	7	7	0	14	320
Calculated	9	6	9	12	16	21	24	27	29	30	28	25	22	18	15	10	7	5	3	4	320
Difference	-9	-1	3	7	7	-1	12	2	0	-1	-3	-11	-10	0	-2	-2	0	2	-3	10	
Monogerm SLC 15 BB_2																					
Obtained	3	34	55	76	67	72	61	60	49	38	31	26	21	11	10	7	4	3	5	7	640
Calculated	23	21	31	45	60	70	76	75	70	56	43	30	18	11	6	3	1	1	0	0	640
Difference	-20	13	24	31	7	2	-15	-15	-21	-18	-12	-4	3	0	4	4	3	2	5	7	

Homogeneity chi square P values showed that the calculated proportion of individuals in the different classes agreed with the obtained proportion only for the inbred. However, the upper ten classes of the F_1 distribution are not different from expected, as was the case when testing whether the F_1 population followed the normal probability integral. Hence the end of the F_1 distribution which is of interest in this problem is not different than the expected distribution.

The means, total variances, within-plot total variances, within-plot environmental variances, and within-plot genetic variances are listed in table 24. From a study of the genetic variances it is clear that the monogerm population is the only one which has a genetic variance significantly different from zero. It should be possible to identify genetically superior individuals and to predict genetic gains in this population.

In table 25 appears the proportion of identified-genetically-superior individuals in each population and the predicted mean of a theoretical population from which the identified-genetically-superior individuals are considered as chance deviates. These methods are taken from Powers [2, 4, 5]. In studying the monogerm population, the value 3.60 in column 2 of table 25 means that the probability is less than 0.001 that any roots will be heavier than 3.60 pounds by chance alone. Therefore, in table 23 the 12 roots in the two highest classes can be considered identifiable genetically superior individuals. Then if these 12 roots which represent 1.9 percent of the population were to be included as chance deviates in a normally distributed population they would represent those individuals above a truncation line which lies 2.08 standard deviations above the mean of the theoretical population. From this it is possible to calculate this theoretical mean, using methods from Powers [4, 5]. In the monogerm population SLC 15 BB_2, this predicted mean is 2.13 pounds per rdot. Considering the methods used in making the calculations, it can be said that this should be a conservative estimate. This represents an increase of 53.2 percent which would be a marked advance in weight per root. It remains to be seen by further experiments how much of this mean value can be attained by selection and other breeding methods.

Table 24. Means, total variances, within unit total variances, within unit environmental variances, and within unit genetic variances; weight per root.

Population	Mean	Variance			
		Total	Within units		
			Total	Estimated environmental	Genetic
Inbred	0.917	0.13485±0.010678	0.127357±0.011436	0.127024±0.016000	0.000333±0.017753
F_1	1.849	0.85455±0.067664	0.740997±0.081588	0.741309±0.047597	-0.000312±0.059917
SLC 15 BB_2	1.386	0.62928±0.035205	0.595141±0.045206	0.436235±0.024312	0.158906±0.033470

Table 25. Percentage of identified-genetically-superior individuals and estimated means of the frequency distributions in which these individuals would occur; weight per root.

Population	Value of [illegible] used (p less than 0.001)	Total environmental standard error 1/	Superior individuals	Value of x'	Mean	
					Obtained	Predicted from superior individuals
			%			
Inbred 34	2.20	0.36722	0.0	----	0.917	----
F_1 (52-430 X 52-407)	4.60	0.92442	0.0	----	1.849	----
SLC 15 BB_2	3.60	0.70499	1.9	2.08	1.386	2.13

1/ The variance giving rise to the environmental standard error for the segregating population was calculated by regression using the population mean and the relation between the means and total variances found in the Inbred and F_1.

Percentage Sucrose and Weight Per Root

Both characters will now be considered simultaneously, as must be the case in any actual breeding program. In table 26 is the bivariate frequency distribution of percentage sucrose and weight per root for the monogerm population. In table 21 it was determined that the identified-genetically-superior individuals exceeded 15.75 percent sucrose, and in table 23 it was determined that the identified-genetically-superior individuals exceeded 3.60 pounds per root. Hence the percent of identified-genetically-superior individuals in this monogerm population is 0.94% for percentage sucrose and 1.9% for weight per root. If these two characters are independent, the expected proportion of the population exceeding the upper class limits for both characters would be the product of their separate probabilities. For this population the joint probability would be 0.019 times 0.009 or 0.000171. Thus, assuming independence, approximately two individuals per ten thousand would be expected to fall into classes that would make them identifiable as genetically superior for both characters. Thus, in this population of 640 individuals, no individuals superior for both characters would be expected to be found, and none were found as is shown in table 26.

In looking further at table 26 there is an apparent positive relation between percentage sucrose and weight per root. Using methods from Powers [5], in table 26 the solid line delimits those individuals that exceed the limits of the class in which the means of the characters fall. For percentage sucrose, the percent of the population falling above 12.00 is 46.1%. For weight per root, 42.5 percent of the population fall above the mean class. The expected percentage for both characters on the basis of independence is the product of 46.1 and 42.5, or 19.6 percent. The obtained percent is 25.6. Therefore, from 640 individuals 125 are expected and 164 are obtained. The chi square for testing whether the ratios 515:125 and 476:164 are different has a P value of less than 0.01. Thus, the characters are not independent in the monogerm population. They are positively related. This relation is further confirmed by a highly significant regression and correlation coefficient for the two characters.

Table 26. Bivariate frequency distribution of Monogerm SLC 15 BB_2 for percentage sucrose and weight of root; in number in each class. Total plants = 640; mean percent sucrose = 11.51; mean weight of root = 1.386.

Weight per root; upper class limit	Percentage sucrose; upper class limit															Total
	0 to 6.00	6.75	7.50	8.25	9.00	9.75	10.50	11.25	12.00	12.75	13.50	14.25	15.00	15.75	over 15.75	
0 to 0.20				1	1				1							3
0.40	5	3	1	3	4	1	1	2	4	2	3	2	2		1	34
0.60	5	3		3	5	7	5	4	5	6	5	2	4	1		55
0.80	2	1	2	2	6	11	11	9	10	5	7	10				76
1.00	4	1		2	3	5	6	11	10	5	9	5	3	3		67
1.20	4	1	2		4	8	4	13	9	8	11	4	1	2	1	72
1.40		1	1	1	3	6	6	9	5	10	9	4	5	1		61
1.60		2	1	2		2	4	3	12	13	10	5	4	1	1	60
1.80					1	2	3	10	11	8	6	4	3	1		49
2.00				1	1	2	2	2	8	6	9	5	2			38
2.20				1				4	4	12	4	2	3	1		31
2.40							1	7	2	6	5	4			1	26
2.60					1	1	1	3	1	5	6		1	1	1	21
2.80								2	2	1	1	3		1	1	11
3.00									3	2	3		2			10
3.20								1	1	2	1	1	1			7
3.40								1		1	1	1				4
3.60										1			2			3
3.80						1		1		1	1	1				5
over 3.80								1		1	1	2	1	1		7
Total	20	12	7	16	29	46	44	83	88	95	92	55	34	13	6	640

In the analysis of the covariances of percentage sucrose and weight per root the within-plot total covariances and their errors are as follows: inbred (0.04816 ± 0.029493), F_1 (0.02746 ± 0.080135), monogerm (0.55863 ± 0.07724). Thus, the non-segregating populations have no significant covariance. The genetic covariance of the monogerm population is 0.52082 ± 0.08549. The analysis of variance of the within-plot covariances shows that the odds are less than 19:1 that there is a difference in covariances due to units or samples. This would indicate that the covariance between weight per root and percentage sucrose is at least partly genetic.

DISCUSSION

In general most investigators have reported a negative relation between weight per root and percentage sucrose. This relationship could be caused by physiological thresholds, genetic linkage, or pleiotropy. The data of this experiment would seem to lend weight to the hypothesis of genetic linkage and discount the effects of physiological thresholds unless the year effect is extremely great. Pleiotropy is not ruled out by these data.

It was shown earlier that, on the basis of independence, only two beets per ten thousand could be identified as genetically superior for both percentage sucrose and weight per root in the monogerm population. The positive relation between the characters would increase that proportion somewhat. Also, most of the truly genetically superior individuals could not be identified because they could not be separated from the extreme chance deviates. Thus, of the 47 roots selected to go into the 1960 polycross plot, more than just two or three can be expected to be genetically superior. Further research is necessary to determine whether the differences are sufficiently great and the polycross test sufficiently precise to separate the chance deviates from the genetic deviates.

SELECTIVE GAMETOCIDE TEST ON SUGARBEETS

A field experiment designed to study the possibility of chemically inducing male sterility in sugarbeets was conducted in 1960 at Fort Collins, Colorado. This was a continuation of experiments conducted in 1958 and 1959 at Fort Collins and reported in the Sugarbeet Research Report for these years.

The purpose of this study is to determine the effect of three chemicals as selective male gametocides on a wide range of genotypes, using different times and rates of application.

The characters of interest are phytotoxicity rating, delay of flowering date, delay of pollen shedding, seed yield, and percentage germination. The chemicals used are FW-450 (sodium 2,3-dichloroisobutyrate), FW-676, and G-315.1/ FW-450 was used in the 1958 and 1959 experiments. FW-676 and G-315 are related compounds of sodium 2,3-dichloroisobutyrate and are used for the first time on sugarbeets in this experiment. There are two heterogeneous populations included in the study--A54-1, a multigerm commercial variety; and SLC 15 BB_2, a monogerm broad-base population.

The experimental design is a modified split plot with three replications. The whole plots are treatments, with populations as sub-plots. There are nineteen whole plots or treatments which are listed in table 27. These treatments consist of the three chemicals, each applied at three concentrations and two application intervals and a check, making a total of (3 X 3 X 2) + 1 or nineteen treatments. The design is modified by arranging every third whole plot to be a check plot. Hence every treated plot was bordered on one side by an untreated plot, which assured an ample pollen supply within the experiment. The means for the check are therefore based on nine plots per replication and should be highly reliable. The treated whole plots were randomized within each replication after the check plots were assigned and sub-plots were randomized within whole plots. There are four plants per whole plot and thus two plants per sub-plot.

The application intervals are four and seven days. Treatment was commenced for each plant when the seed stalk was twelve to fifteen inches tall and continued until seed stalk growth was nearly complete, the flowering period being quite determinate in the Fort Collins area. Those plants treated on four-day intervals received ten applications and those treated on seven-day intervals received six applications.

The concentrations applied were 0.1, 0.2 and 0.3 percent. All concentrations were applied in an aqueous solution at a carrier rate of 100 gallons per acre. Thus the applications were at 0.83, 1.67, and 2.50 pounds per acre, respectively. A shield was used in application, eliminating drift as

1/ The chemicals used were supplied by Rohm & Haas Company, Philadelphia, Pa.

Table 27. Mean phytotoxicity rating, number of days from June 15 to first flower, number of days from first flower to first dehiscence of pollen and percentage of plants shedding pollen, seed yield per plant in grams, and percentage germination for the treatments applied in the 1960 gametocide experiment.

Treatment	Phytotoxicity rating 1/		Days June 15 to first flower		Days first flower to to first pollen and % of plants shedding pollen		Seed yield per plant		Percentage germination	
	Mono	Multi	Mono	Multi	Mono	Multi	Mono	Multi	Mono	Multi
	Rate	Rate	Days	Days	Days %	Days %	Grams	Grams	%	%
FW-450, 0.1%, 4 days	2.6	2.6	12	7	12.2(80%)	6.8(100%)	15.2**	201.8**	15.3**	42.0**
FW-450, 0.2%, 4 days	4.5	3.2	11	6	(0%)	12.5(67%)	3.3**	136.8**	13.0**	37.0**
FW-450, 0.3%, 4 days	4.7	3.5	19*	12*	(0%)	25.0(33%)	0.5**	96.8**	0.3**	25.3**
FW-450, 0.1%, 7 days	1.8	1.2	10	6	8.8(100%)	3.0(100%)	33.8**	360.2	41.0	73.3**
FW-450, 0.2%, 7 days	3.4	2.2	18*	7	7.0(17%)	3.7(100%)	2.3**	184.0**	13.0**	66.3**
FW-450, 0.3%, 7 days	4.2	2.7	12	8	15.0(17%)	5.8(100%)	3.7**	176.1**	12.3**	56.7**
FW-676, 0.1%, 4 days	2.5	1.7	8	6	16.0(67%)	2.7(100%)	28.5**	240.6**	35.3**	76.0**
FW-676, 0.2%, 4 days	3.5	3.2	15	6	1.0(17%)	4.4(100%)	1.7**	167.6**	1.7**	60.0**
FW-676, 0.3%, 4 days	4.7	4.2	17	11*	24.0(25%)	16.0(83%)	17.0**	77.8**	2.3**	41.0**
FW-676, 0.1%, 7 days	1.6	1.2	12	7	7.7(80%)	1.8(100%)	31.8**	256.5*	35.7**	64.3**
FW-676, 0.2%, 7 days	2.0	1.2	11	5	8.2(67%)	3.0(100%)	32.2**	224.6**	37.7**	71.7**
FW-676, 0.3%, 7 days	3.2	2.6	8	7	22.5(40%)	4.3(86%)	14.2**	164.0**	15.3**	52.0**
G-315, 0.1%, 4 days	3.3	2.2	10	8	10.2(67%)	4.8(100%)	24.2**	231.3**	36.0**	53.7**
G-315, 0.2%, 4 days	4.0	2.7	18*	5	16.5(40%)	8.7(100%)	10.0**	225.1**	12.0**	52.3**
G-315, 0.3%, 4 days	4.7	3.8	10	8	(0%)	12.7(67%)	0.2**	105.7**	0.0**	22.3**
G-315, 0.1%, 7 days	1.7	1.0	6	6	8.2(100%)	2.0(100%)	43.7**	337.3	52.0	86.0
G-315, 0.2%, 7 days	1.7	2.0	8	5	11.3(60%)	2.5(100%)	17.2**	230.8**	23.0**	79.3**
G-315, 0.3%, 7 days	3.5	2.0	14	5	9.7(50%)	3.8(100%)	14.8**	169.6**	8.0**	51.0**
Check	1.0	1.0	8	6	1.6(100%)	0.6(100%)	88.4	381.2	47.0	89.7

* Odds are greater than 19:1 that these means are not chance deviations from the check.
** Odds are greater than 100:1 that these means are not chance deviations from the check.
1/ Rating from 1 to 5; 1 = no toxic effect, 5 = severe toxic effect.

a factor in the experiment. The rows were spaced three feet and plants within rows were spaced three feet. This greatly facilitated movement of spraying equipment within the experimental area. Disease was not a factor in the experiment.

The means for the characters, phytotoxicity rating, number of days from June 15 to first flower, number of days from first flower to first pollen shedding, seed yield per plant in grams, and percentage germination are shown in table 27.

The phytotoxicity rating is an arbitrary scale where a rating of one indicates no toxic effect and a rating of five indicates a severe toxic effect with burning of the flowering branches so that flowering took place only on the lower portions of the branches. From table 27 it is evident that all treatments had at least some injurious effect except the chemical G-315 applied in a 0.1% concentration at seven-day intervals. In every treatment except one, the monogerm population was more severely affected than was the multigerm population. The degree of injury was directly related to the concentration and interval of application. The analysis of variance in table 28 indicates a significant difference between treatments and populations. A separate analysis of variance, not tabulated, indicated that there were no differences between chemicals.

From table 27 there were only four treatments which significantly delayed flowering. Thus flowering date was not greatly affected. There was no difference between chemicals. However, in table 28 it is shown that populations were different with flowering being delayed longer in the monogerm than in the multigerm material.

In considering the character, days from the first flower to the first pollen, a plant was considered to be shedding pollen when two flowers on at least two flowering branches could be found which had normally dehiscent anthers and visible pollen. In general, when this pollen shedding criterion could be met there were many more than just two flowers on two branches with visible pollen. Since many of the plants shed no pollen, the data were not subject to analysis of variance. However, the mean number of days from the first flower to the first pollen and the percentage of plants shedding pollen yield some information. In every treatment except one, the pollen sterile period is longer for the monogerm population. In every treatment where some plants failed to shed pollen, the percentage of plants shedding pollen is lower for the monogerm population. Thus there are observable differences between populations and between treatments. There are no readily evident differences between chemicals.

Mean seed yields in table 27 show that most treatments significantly reduced the seed yield per plant. In the monogerm population seed yield was significantly reduced by all treatments. In the multigerm population only two treatments did not reduce seed yield significantly. In table 28 there are significant differences between treatments and populations and a significant treatment X population interaction.

Table 28. Analyses of variance of phytotoxicity rating, number of days from June 15 to first flower, seed yield per plant, and percentage germination for the 1960 gametocide experiment.

Source of variation	Degrees of freedom	Mean square			
		Phytotoxicity rating	Days June 15 to first flower	Seed yield per plant	Percentage germination
Whole plots					
Replications	2	0.45	10.02	6315.45	19.50
Treatments	18	6.65**	42.26**	15681.68**	1742.46**
Reps. X Trmts. (Error a)	36	0.28	14.92	1940.91	277.71
Split plots					
Populations	1	19.54**	673.06**	1056103.12**	38573.80**
Trmts. X Pops.	18	0.30	17.30	6790.99**	196.84
Residual (Error b)	37	0.45	32.14	2438.52	228.29
Total	112 1/				

1/ One missing plot.

** Odds are greater than 100:1 that these means are not chance deviations from the check.

In the germination studies a seed ball having at least one sprout was classed as having germinated. Thus the multigerm population would be expected to have a higher germination percentage. The data in table 27 support this contention. It is also noted in table 27 that only two treatments did not significantly reduce the percentage germination. From table 28 the differences between treatments and between populations are highly significant. In an analysis, not tabulated, no differences could be demonstrated between chemicals.

Considering all characters, it can be concluded that the monogerm population is more sensitive to all treatments than is the multigerm population. Induced male sterility was greater in the monogerm than in the multigerm population but also it was accompanied by an increase in female sterility.

Of the three chemicals tested, no differences in reaction of the treated material could be detected. Neither was there a chemical by population interaction. However, the delay of pollen shedding is indicative of some selective male gametocide action. Also, the reduction in germination as the severity of the treatment increases indicates that increasing male sterility is accompanied directly by increased female sterility.

The undesirable effects resulting from treatment with the three chemicals tested appear to seriously limit their use as selective male gametocides in a commercial hybrid program. Their action is not sufficiently selective between the male and female gametes. Also, the reduction of seed yield is a serious consideration in commercial seed production. The chemicals tested undoubtedly have some utility as a breeding tool to obtain crosses between self-fertile lines and other hybrids were seed quantity and quality are of secondary interest.

LITERATURE CITED

1. Pearson, K. 1930. Tables for statisticians and biometricians. Part 1, Ed. 3, 143 pp., illus. Cambridge.

2. Powers, L. 1942. The nature of the series of the environmental variances and the estimation of the genetic variances and the gometric means in crosses involving species of Lycopersicon. Genetics 27:561-575.

3. Powers, L. 1950. Determining scales and the use of transformations in studies on weight per locule of tomato fruit. Biometrics 6:145-163.

4. Powers, L. 1951. Gene analysis by the partitioning method when interactions of genes are involved. Bot. Gaz. 113(1):1-23.

5. Powers, L. 1957. Identification of genetically superior individuals and the prediction of genetic gains in sugar beet breeding programs. Jr. Amer. Soc. Sugar Beet Tech. IX(5):408-432.

6. Powers, L., Robertson, D. W., and Clark, A. G. 1958. Estimation by the partitioning method of the numbers and proportions of genetic deviates in certain classes of frequency distributions. Jr. Amer. Soc. Sugar Beet Tech. IX(8):677-696.

PART IX

RHIZOCTONIA INVESTIGATIONS

Inoculation Techniques and Selecting for Resistance

Foundation Project 25

J. O. Gaskill

Research conducted in cooperation with the Botany and Plant Pathology Section, Colorado Agricultural Experiment Station.

RHIZOCTONIA INVESTIGATIONS FORT COLLINS, COLORADO, 1960 1/

(A phase of Beet Sugar Development Foundation Project 25)

John O. Gaskill 2/

During 1960, major emphasis was given to the screening of foreign introductions of *Beta vulgaris* for resistance to *Rhizoctonia solani*. Testing of resistance of progenies of sugar beet selections, made at Fort Collins, was continued but on a smaller scale than in the preceding year. An experiment concerning the effects of soil amendments on Rhizoctonia attack, begun in the fall of 1959 and concluded in 1960, represented a substantial amount of space and effort. The results presented in this report were obtained in field plots on the Hospital Farm, Fort Collins, Colorado.

Screening Test of Foreign Introductions

Seed of 226 introductions of *Beta vulgaris*, from many parts of the world, was obtained from the Regional Plant Introduction Station of the U. S. Department of Agriculture, Ames, Iowa. Most of this material represented culinary forms of beet in the country of origin, though some mangels and sugar beets were included.

The entire set of 226 seed lots was planted in 1-row plots, 23 feet long, in an experiment designated "R-2". With the exception of 2 lots, there were 2 plots of each. A modified randomized-block design was used, with extra plots of a check variety, US 401. Planting was done June 29-30, and thinning was performed at about the usual stage of plant development (July 25-27), attempting to leave approximately 9-inch spacing in the row. Seven to 10 days after thinning, a 14-foot section of row in each plot was inoculated with a highly pathogenic isolate of *Rhizoctonia solani* (#B-6). Dry, ground, barley-grain inoculum was used --- one-sixth teaspoon per plant, placed in a semi-circle one and one-half inches from the tap root and about 1 inch below the soil surface. Irrigation was performed entirely by sprinkler. At harvest (October 20-21) all living plants in the inoculated section of each plot were dug by hand, the roots were examined, and

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the plot was classified on the basis of the degree of apparent Rhizoctonia injury to the plot as a whole. Each plot also was classified as to degree of bolting. The latter readings were based largely on the non-inoculated sub-plots.

As may be noted in Figure 1, Rhizoctonia injury was extremely severe among inoculated plants as a whole. None of the 226 introductions tested was outstanding in resistance. However, using an ascending scale of disease severity, 10 introductions were assigned a grade of 4 as compared with 5+ for the sugar beet check variety, US 401(Table 1,2). Only 1 of 20 plots of the latter was rated 4. All others were classed as 5 or 6. It should be noted that all of the introductions assigned a disease grade of 4 were classed as annuals or nearly so (bolting ratings 5 and 4). This poses the question of a causal relationship between annualism and apparent resistance to or escape from Rhizoctonia. In this connection, however, it should be noted that, of the introductions in bolting classes 4 and 5, the number rated highly susceptible (disease grade 6) actually exceeded the number rated slightly resistant (grade 4). Thus it appears that annualism was not necessarily associated with reduced severity of Rhizoctonia attack in this experiment.

Although none of the 226 introductions tested were outstanding in Rhizoctonia resistance, under the conditions of this experiment, the results indicate the desirability of further study of certain numbers. Biennial roots with apparent resistance, selected from a number of lines at harvest, are to be brought to seed and the progenies tested for resistance in order to determine whether further selection and/or crossing with agronomically desirable sugar beet types would be worthwhile. Work also is under way in an attempt to determine whether bonafide resistance, independent of the annual character, is present in certain of the annual lines, and whether genes controlling such resistance can be transferred to biennial types.

Figure 1. View of Rhizoctonia experiment R-2 (B. vulgaris introductions), Fort Collins, Colorado, October 8, 1960, showing inoculated and non-inoculated sections of a series of 1-row plots. The tall, white stake in the foreground is in the first row of the series and marks the point dividing inoculated (left) and non-inoculated sections.

Table 1. Frequency distribution of 226 *Beta vulgaris* introductions according to bolting tendency and reaction to *Rhizoctonia solani* (Fort Collins Exp. R-2, 1960).

Bolting a/ classification	Disease grade b/ and no. of introductions c/ 4	5	6
0		48 (4)	31 (7)
Tr.		9 (1)	15 (2)
1		13	9
2		3	7 (2)
3		4	5
4	1	14	6
5	9	25 (1)	8 (2)

Bolting classification and disease grade for US 401 were 0 and 5+, respectively (20-plot averages).

a/ Bolting classifications: 0 = no bolters; Tr. = trace; 5 = approximately 100% bolters (9/22-23/60).

b/ Basis for disease grades (Rhizoctonia): 0 = all plants healthy or nearly so; 6 = all plants dead or severely damaged (10/20-21/60).

c/ Numbers in parentheses indicate numbers of lines (introductions) for which there were less than 20 inoculated plants, each. For all other lines, there were at least 20 inoculated plants, each (usually more than 30).

Note: Individual performances of entries shown in Table 2.

Table 2. Test of Beta vulgaris introductions for Rhizoctonia resistance. (Fort Collins Exp. R-2, 1960)

(Results given as 2-plot averages except where otherwise indicated)

Source	Designated type	P.I. no.	Bolting class. a/	Disease grade b/	Remarks
China	Garden	103042	1	5	
do		105335	0	5	
Turkey		109038	5	5	
do	Gard.	109039	Tr.	6	
do	Mangel	109040	0	5	
China	Mangel	113306	0	5	
India	Gard. leafy	116808	5	5	
do	do	116809	5	5	
do	do	116810	Tr.	5	
Afghan.		116906	4	6	
Turk.	Mangel	117113	3	5	
do	do	117114	0	5	
do	do	117115	2	6	
do	do	117116	1	6	
do		117117	Tr.	6	
India		119892	5	6	
Turk.	Mangel	120282	Tr.	6	
do		120688	0	6	
do	Mangel	120689	0	5	
do		120690	4	5	
do	Mangel	120691	0	5	
do	do	120692	4	5	
do	do	120693	Tr.	6	
do	do	120694	0	5	
do	do	120695	0	5	
do	Sugar	120696	Tr.	6	
do		120697	3	6	
do		120699	Tr.	5*	
do	Mangel	120700	Tr.	5	
do		120701	5	5	
do		120702	2	6	
do	Mangel	120703	1	5	
do	do	120704	Tr.	6	
do	Sugar	120705	0	5	
do		120706	Tr.	6	
do		120707	0	6	
India		121296	5	6*	1 plot
do		121297	5	6	
do		121838	5	5	
do		124404	5	5	
do		124528	0	6	
Iran		140353	Tr.	6	

a/ b/ — See last page

Table 2 (cont.)

Source	Designated type	P.I. no.	Bolting class.	Disease grade	Remarks
Iran		140354	1	6	
do		140355	1	5	
do		140356	2	6	
do		140357	1	6	
do		140359	Tr.	6	
do		140360	Tr.	5	
do		140361	Tr.	6	
do		140362	1	6	
Manchuria		141919	Tr.	6	
Iran		142808	Tr.	6	
do		142810	Tr.	6	
do		142811	1	6	
do		142812	0	6	
do		142816	0	6	
do	Mangel	142817	0	5	
do	Sugar	142818	0	6*	
India	Gard.-leafy	163176	5	5	
do	do	163177	5	6	
do	Table	163178	0	6	
do	do	163179	0	5	
do	Gard.-leafy	163180	5	6	
do	do	163181	5	5	
do	Table	163182	0	6	
do	Gard.-leafy	164172	5	4	
do	Table	164292	0	5	
do	Gard.-leafy	164355	5	6	
do	do	164363	5	5	
do	do	164495	5	5	
do	do	164524	5	4	
do	do	164553	5	5	
do	Gard. beet	164659	0	5	
do	Gard.-leafy	164671	5	5*	
do	do	164747	5	5	
do	Gard. beet	164805	0	5	
do	Gard.-leafy	164806	5	4	
do	do	164810	5	5	
Turk.	Gard. beet	164968	0	5	
do	Gard.-leafy	164978	2	6**	
do	Sugar beet	165013	0	6	
do	Mangel	165037	0	5	
do	Sugar beet	165062	0	5	
India	Gard. beet	165485	0	6	
do	Gard. leafy	165502	5	5	
Turk.	Mangel	167374	0	6	
do	Sugar beet	169014	0	6	
do	Gard. beet	169015	0	6	
do	Sugar beet	169016	0	5	

Table 2 (cont.)

Source	Designated type	P.I. no.	Bolting class.	Disease grade	Remarks
Turk.	Mangel	169017	0	5	
do	Sugar beet	169018	0	5	
do	Gard. beet	169019	0	5	
do	Sugar beet	169020	0	5	
do	Gard.-leafy	169021	3	5	
do	Gard. beet	169022	1	5	
do	do	169023	0	6	
do	Sugar beet	169024	0	6	
do	do	169025	0	5	
do	Mangel	169027	0	5	
do	Gard. beet	169028	0	5	
do	do	169029	Tr.	5	
do	do	169030	0	6	
do	Sugar beet	169031	0	5	
do	Gard. beet	169032	0	5	
do	do	171504	1	5	
do	Mang. or sugar	171505	2	6	
do	Mangel	171506	1	5	
		171507	0	6*	1 plot
Turk.	Sugar beet	171508	Tr.	6*	
do	Mangel	171509	0	5	
do	do	171512	0	5	
do	do	171513	0	6*	
do	Sugar	171515	2	6	
do	Mangel	171516	0	5*	
do	Sugar beet	171517	0	5	
do	Mangel	171518	0	5	
do	do	171519	0	6	
do	do	171520	1	5	
do	do	172729	0	6	
do	do	172730	3	6	
do	Gard. beet	172731	4	5	
do	Mangel	172732	5	5	
do	do	172733	1	5	
do	do	172734	0	5	
do	Gard.-leafy	172735	5	4	
do	do	172736	4	6	
do	do	172737	4	5	
do	Table leafy	172739	2	5	
do	Mangel	172740	Tr.	5	
do	Gard.-leafy	172741	3	6	
do	Mangel	173641	0	6	
do	Table	173642	3	6	
India	Gard.-leafy	173841	5	5	
do	Gard.	173842	0	5	
do	Gard.-leafy	173843	5	4	
do	Gard.	173844	Tr.	5	

Table 2 (cont.)

Source	Designated type	P.I. no.	Bolting class.	Disease grade	Remarks
Turk.	Mangel	174058	3	5	
do	Gard. beet	174059	1	6	
do	Sugar beet	174060	4	5	
do	do	174061	4	6	
do	do	174062	4	6	
do	Mangel	174063	0	6	
India	Gard. beet	174792	5	5	
do	Gard.-leafy	175046	5	4	
do	Gard.-leafy	175047	5	6	
Turk.	Sugar beet	175594	0	5	
do	do	175596	4	5	
do	Mangel	175597	0	6	
do	do	175598	1	6	
do	Sugar beet	175599	0	5	
do	Mangel	175600	0	5	
do	Sugar beet	175601	0	6	
do	Mangel	176421	Tr.	6*	
do	Sugar	176423	0	6*	
do	Sugar beet	176424	0	6	
do	Mangel	176426	0	6	
do	do	176427	4	4	
do	do	176429	4	5	
do		176432	0	5	
do	Mangel	176872	3	5	
do	do	176873	2	5	
do	do	176875	3	6	
do	Sugar beet	177269	0	6*	
do	Mangel	177271	4	5	
do	Gard. beet	177272	5	6	
do	Mangel	177273	0	5	
Syria	Gard.-leafy	177274	Tr.	5	
do	Gard. beet	177275	0	5	
do	do	177276	4	5	
Turk.	Sugar	178836	2	5	
do	Mangel	178837	0	5	
do	Sugar beet	179173	0	5	
do	do	179174	0	5	
Iraq	Gard.-leafy	179175	4	6	
do	Sugar beet	179176	5	6	
Turk.	Gard. beet	179178	5	5	
Syria		179179	4	5	
Turk.	Gard.	179180	Tr.	5	
India	Gard.-leafy	179844	5	4	
do	do	179845	5	5	
do	do	180409	5	5	
do	Gard. beet	180410	5	5	
do	Gard.-leafy	181011	5	5	

Table 2 (cont.)

Source	Designated type	P.I. no.	Bolting class.	Disease grade	Remarks
Lebanon	Gard.-leafy	181715	4	5	
do	do	181716	4	5	
		181717	1	5	
Lebanon	Gard.	181718	1	5	
Syria	do	181859	2	6	
do	do	181930	1	6	
do	Gard. chard	181931	4	5	
Turk.	Mangel	182143	0	6	
do	do	182144	0	6	
do	do	182145	Tr.	6	
do		182146	0	6	
Egypt	Mangel	183211	1	6	
Turk.	do	183663	0	6	
Ethiopia	Sugar beet	193457	1	5	
do	Gard.	193458	0	5	
Turk.	Mangel	204677	0	6*	
do	do	204678	0	5*	
Sweden	Table	205987	1	5	
Turk.	Mangel	206407	Tr.	5	
do	Sugar	206408	0	5	
India	Mangel	212883	5	5	
do		212884	5	5	
do	Sugar	215577	5	4	
Pakistan	Mangel	217964	5	4	
do	do	218063	5	5	
Afghan.	Sugar	220165	0	5	
do	Sugar beet	220506	0	6	
do	do	220508	0	6	
do	do	220509	0	6	
do	do	220645	1	5	
do		221436	4	6	
Iran		222233	Tr.	6	
do		222703	0	5	
do	Mangel	222768	0	5	
do	Sugar	222769	0	6*	
do		222970	0	5	
Afghan.	Sugar	223755	2	6	
Burma	Table	224684	0	6	
Iran	Mangel	226628	2	6*	
do		227010	5	6*	
do	Mangel	228340	0	5*	
do	do	229589	0	5*	
do	do	229683	4	5	
U. S.	US 401 (com'l. var.)		0	5+	20 plots

Table 2 (cont.)

a/ Bolting classifications: 0 = no bolters; Tr. = trace; 5 = approximately 100% bolters (9/22-23/60).

b/ Basis for disease grades (root symptoms of Rhizoctonia at harvest): 0 = all plants healthy or nearly so; 6 = all plants dead or severely damaged. Each value given is based on 20 or more inoculated plants (total, both replications) except for the following: * = Grade based on 10-19 inoculated plants (total); ** = Grade based on less than 10 inoculated plants (total).

Note: The experiment consisted of 1-row plots, 23 ft. long, planted June 29-30, and thinned July 25-27. A 14-foot section of row in each plot was inoculated with *Rhizoctonia solani*, August 3-4, using dry, ground, barley-grain inoculum of a virulent isolate (B-6). Inoculation was performed by placing 1/6 teaspoon of inoculum in a semi-circle, approximately 1-1/2 inches from the tap root and 1 inch below the soil surface. Disease grades were based on the condition of the roots at harvest, October 20-21, in the inoculated section of each plot. Rhizoctonia attack was negligible among the non-inoculated plants. Bolting classifications were based largely on the latter.

Progeny Tests

Progeny tests for resistance to a highly pathogenic isolate of Rhizoctonia (no. B-6) involved 15 seed lots representing selection for Rhizoctonia resistance, several commercial varieties, and certain other material. Plot size, timing, and inoculation technique, for the most part, were the same as described for the test of foreign introductions. There was a total of 82 inoculated sub-plots, the number of replications varying according to size of seed lot and objective of test. Rhizoctonia attack was extremely severe, resulting in death of or serious injury to nearly all plants in each population. Differences between populations, in degree of resistance, were considered inconclusive, but outstanding individual plants were selected for further breeding.

In one test involving a synthetic variety (SP 601157-00), having a background of selection for Rhizoctonia resistance, and other material without such background, varietal response to a moderately pathogenic Rhizoctonia isolate (B-12) was compared with response to the highly pathogenic isolate (B-6) referred to above. The reaction to isolate B-6 has been discussed in the preceding paragraph. Isolate B-12 caused some obvious damage to nearly every plant but relatively little death loss. At harvest, each plant inoculated with that isolate was dug and classified for disease reaction. The summarized results (4 replications) showed a significantly lower (i.e. better) average disease grade for SP 601157-00 than for US 401, but SP 601157-00 did not differ significantly from GW 359, C817 (G.W.S. Co.), or SP 5831-0.

Soil Amendments 3/

A field study of the effects of soil amendments on Rhizoctonia was begun in the fall of 1959 in an area which had been fallowed in 1958 and used for growing sugar beets in 1959. The plants in certain blocks were inoculated after thinning, in 1959, using a mixture of pathogenic isolates of Rhizoctonia and resulting in almost complete kill. Relatively little disease was observed in the non-inoculated blocks in 1959.

The soil amendment experiment was arranged in such a way that 2 complete replications occurred within non-inoculated blocks and 4 replications occurred within inoculated blocks. Each replication consisted of 2 main plots with respect to time of treatment, namely: fall and spring. Each main plot consisted of 4 sub-plots representing the following respective treatments, occurring at random: (1) no amendment, (2) chopped barley straw, (3) ammonium nitrate, and (4) barley straw plus ammonium nitrate. Rates of application per acre were approximately as follows: straw, 3 tons; ammonium nitrate, 75 pounds of N. Each entire main plot was rototilled immediately after application of the amendments on that plot. Each sub-plot was 4 rows (80") wide and 16' long, and all counts were made in the 2 inner rows less 2' at each end. The entire experimental area was planted at a uniform seeding rate on April 11, 1960, using seed of the variety, GW 674-56C. Thinning was performed by hand June 15-16, and the field was sprinkler-irrigated as needed.

A composite soil sample was taken from each of the 48 sub-plots in June 1960. One-half of each soil sample was examined to determine the presence of soil fungi by the Mueller-Durrell soil tube technique 4/. This technique is somewhat selective in that the "sugar fungi" such as Rhizoctonia, Fusarium, Pythium and other rapidly growing mycelial forms are more readily "trapped" in the soil tubes. The second half of each soil sample was planted to sugar beet seedlings in the 4 leaf stage to ascertain the inoculum potential of Rhizoctonia in each sub-plot. A measure of this value was determined by recording beet seedling survival 21 days after transplanting.

3/ The phase of this study pertaining to soil microflora determinations was conducted by Dr. Jack Altman, Botany and Plant Pathology Section, Colorado Agr. Exp. Station.

4/ Mueller, R. E. and L. W. Durrell. 1957. Sampling tubes for soil fungi. Phytopathology Vol. 47, p. 243.

Field Results (Stand):

Stand counts made immediately before thinning indicated that both the straw treatments had afforded some protection against seedling disease. However, for all practical purposes, this effect disappeared before harvest in the 4 replications which had been inoculated in the preceding year. In fact, Rhizoctonia attack was so extremely severe in those replications that, in the inner rows of the entire set of 32 sub-plots, only 11 plants remained alive at harvest. Three of those 11 plants occurred in non-straw plots. Under less severe Rhizoctonia exposure, in the 2 replications which had not been artificially inoculated in the preceding year, there was some evidence of a protective effect of straw, as seen at harvest. With fall and spring treatments combined, average stands at harvest, expressed as percentages of thinned stands, were as follows:

Treat. no.	Description	Survival (%)
1	No amendment	18.1
2	Straw	32.5
3	Ammonium nitrate	26.8
4	Straw + ammonium nitrate	37.9

Analysis of variance for the 16 sub-plots represented by the above averages, using survival percentages converted to degrees, failed to show the occurence of significant differences among the 4 treatments. Likewise, the general mean difference between straw and non-straw treatments was not significant.

Results of Soil Microflora Studies
(Summary by J. A. Altman)

In the soil samples, from the non-inoculated areas, that were examined for fungi in the laboratory and planted to sugar beet seedlings in the greenhouse, a definite trend regarding Rhizoctonia reduction and, as a consequence, Rhizoctonia infection in the seedlings, seemed to be established. The addition of barley straw, whether supplemented with ammonium nitrate or not, reduced the incidence of Rhizoctonia. This is borne out not only by the data from the soil tube isolations but also by the data from the seedling survival test. The percentage of Rhizoctonia isolated from the non-amended and ammonium-nitrate amended soils was greater than that isolated from sub-plots amended with barley straw and barley straw plus ammonium nitrate. In the seedling survival test, the percentage of surviving plants was greater for the sub-plots receiving barley straw amendment than for the non-amended or ammonium-nitrate amended plots. It should be noted that the term, "non-inoculated", refers to treatment in 1959. Actually, in areas so designated, the soil contained considerable Rhizoctonia inoculum in 1960 as a result of inoculation in 1957 and/or dissemination by wind, cultivator tools, etc.

No trends toward Rhizoctonia reduction were established for the inoculated blocks. Perhaps inoculation resulted in such a high inoculum level that the effect of any soil amendment may have been completely overcome. This conclusion, based on the results of soil tube isolations and the greenhouse seedling survival test, is in agreement with the field stand results.

COMPARISON OF RUSSIAN AND AMERICAN MONOGERM STRAINS AS POLLINATORS FOR PRODUCTION OF HYBRIDS

Fort Collins, Colorado, 1960

John O. Gaskill and Joseph A. Elder

Since the seed of two Russian monogerm introductions, received late in 1958, represented a source or sources different from that from which American monogerm material had been derived, it seemed desirable to compare Russian and American strains or varieties as pollinators for the production of hybrids.

Material and Methods:

Four cytoplasmic-male-sterile (CMS), American monogerm lines, with varying degrees of leaf spot resistance, were used as ♀ parents. One of these (SP 561609-01), the MS equivalent (E_4) of a monogerm inbred, is quite uniform. The other 3 (see table 1) are MS equivalents (E_2 or E_3) of "short-time" inbreds. They are rather lacking in uniformity and may include some out-cross contaminants.

The following pollen-fertile, monogerm strains or varieties were used as pollinators:

1. Acc. 2198: P.I. 254575; Russian monogerm from Belaya Tserkov Station. The original seed lot was approximately 88% monogerm type.

2. Acc. 2199: P.I. 254576; Russian monogerm from Yaltushkov Station. The original seed lot was only about 35% monogerm.

3. SP 5832-0: American monogerm, synthetic variety, resistant to leaf spot and black root.

4. SP 571004-0: American monogerm, synthetic variety, resistant to leaf spot.

At the time Russian seed arrived (December, 1958), mother roots of SP 5832-0, SP 571004-0, and SP 561609-01 were available for use in hybridization. A seedling photothermal induction technique was used to prepare plants of each of the other 5 strains for hybridization. During April, 1959, mother roots and seedlings were transplanted in 4 isolated field plots, each containing one of the pollinator strains and a complete set of the 4 CMS strains. Potential pollen-producers were rogued in all the CMS strains. Obvious multigerm plants were rogued in all the American strains --- CMS as well as pollinator strains. However, it seemed pre-

ferable to avoid selective handling of the Russian material, and no roguing was done in those 2 strains. At least 0.6 pound of seed was harvested from each of the 4 CMS strains in each of the 4 seed plots.

The 16 monogerm, hybrid seed lots, described above, were planted in the leaf spot field on the Hospital Farm at Fort Collins, on April 26, 1960, for agronomic test, together with seed of the 4 ♂ parents and 4 check varieties. An equalized-random-block design was used with 1-row, 24-ft. plots and 8 replications. The leaf spot epidemic was late, reaching peak stage about September 20, and was classed as moderate in severity. Stand was satisfactory in all plots. All roots in 21 ft. of row in each plot were topped by hand, washed, weighed, and analyzed as a composite sample for sucrose percentage. Harvesting was performed October 21 - 24.

Results:

Harvest results and leaf spot readings obtained in the agronomic test described above (Exp. 1A, 1960) are presented in Table 1. In addition, estimated harvest results and leaf spot readings are shown in that table for the 4 CMS strains. Because those strains were expected to be relatively low in yielding ability, they had been grown in a separate test (#2A) in which 3-row plots were used to avoid border effects. The results obtained in that test (4 replications) were adjusted, so as to apply to experiment 1A, through the use of certain strains common to both tests.

Of the 2 American monogerm strains used as pollinators, SP 5832-0 and SP 571004-0, the latter was substantially the better in that its hybrids were significantly above the hybrids obtained from SP 5832-0 in average root yield, sucrose percentage, and gross sucrose yield. The difference between the 2 sets of hybrids, in average leaf spot reading, was relatively slight and was considered unimportant insofar as agronomic comparisons are concerned.

The hybrids obtained from the higher yielding of the 2 Russian monogerm strains, Acc. 2199, were significantly above the hybrids obtained from SP 571004-0 in average root yield and gross sucrose yield, with only a very slight mean difference in sucrose percentage. It should be noted that the superior yield averages (roots and sucrose) shown for the former group of hybrids are due to the outstanding performance of one particular hybrid having SP 571702-01 as the ♀ parent.

In comparing the hybrids obtained from SP 571004-0 with those having the lower yielding Russian monogerm strain (Acc. 2198) as the ♂ parent, it may be seen that the latter group of hybrids was almost significantly higher in average root yield, significantly lower in sucrose percentage, and only slightly higher in gross sucrose yield. It is of special interest to note that the leading hybrid in this set, in gross sucrose yield, had the same ♀ parent as did the very outstanding hybrid obtained from the other Russian pollinator.

Table 1. Comparison of Russian and American monogerm strains as pollinators (Fort Collins, exp. no. 1A, 1960).

Attribute	Performance of	CMS ♀ (mm)	Pollinators (monogerm) a/ Russian Acc. 2198	Russian Acc. 2199	American SP 5832-0	American SP 571004-0	Aver.	Check varieties a/ SP 5831-0 (mm)	US 401 (MM)	SP 5481-0 (MM)	GW 674 (MM)	Est. b/ performance of CMS strains
Roots per acre (tons)	Pol. & Cks.		14.50	17.21	14.83	15.48	15.51	13.62	16.47	16.65	20.47	
	Hybrids	SP 561609-01	17.24	15.89	15.28	16.39	16.20					12.15
	"	SP 571702-01	19.40	20.46	15.98	16.27	18.03					12.67
	"	SP 571704-01	17.29	17.25	14.49	18.34	16.84					10.96
	"	SP 581756-01	16.42	17.65	16.48	16.49	16.76					13.27
	"	Average	17.59	17.81	15.56	16.87						
			LSD c/: (1) = 1.46; (2) = 0.73									
Sucrose (%)	Pol. & Cks.		15.02	15.35	15.93	16.29	15.65	16.09	15.81	15.82	16.54	
	Hybrids	SP 561609-01	17.00	17.41	17.23	17.26	17.23					17.57
	"	SP 571702-01	16.17	16.61	16.19	16.63	16.40					16.09
	"	SP 571704-01	15.96	15.96	15.75	16.02	15.92					15.26
	"	SP 581756-01	16.46	16.47	16.49	16.73	16.54					16.50
	"	Average	16.40	16.61	16.42	16.66						
			LSD c/: (1) = 0.45; (2) = 0.22									
Gross sucr. per acre (tons)	Pol. & Cks.		2.176	2.648	2.366	2.530	2.430	2.191	2.604	2.635	3.388	
	Hybrids	SP 561609-01	2.930	2.764	2.631	2.829	2.789					2.137
	"	SP 571702-01	3.136	3.406	2.591	2.705	2.960					2.043
	"	SP 571704-01	2.759	2.756	2.296	2.940	2.688					1.672
	"	SP 581756-01	2.702	2.904	2.723	2.762	2.773					2.182
	"	Average	2.882	2.958	2.560	2.809						
			LSD c/: (1) = 0.268; (2) = 0.134									
Leaf d/ spot (9/21)	Pol. & Cks.		4.6	4.1	1.9	1.7	3.08	1.8	2.4	1.9	2.6	
	Hybrids	SP 561609-01	3.5	3.5	2.5	2.4	2.98					3.5
	"	SP 571702-01	3.1	2.8	2.1	1.9	2.48					2.1
	"	SP 571704-01	2.1	2.4	1.9	1.1	1.88					0.5
	"	SP 581756-01	2.8	3.6	2.3	1.9	2.65					1.7
	"	Average	2.88	3.08	2.20	1.83						

a/ Basic data presented as 8-plot averages.

b/ Estimates based on results from a separate test (4-plot averages).

c/ LSD (5% point): (1) for comparison of 8-plot averages; (2) for comparison of 32-plot averages.

d/ Basis of leaf spot readings: 0 = no leaf spot; 10 = complete defoliation.

In appraising the harvest results obtained for the hybrids having Russian monogerm strains as the ♂ parents, it should be noted that this material was less resistant to leaf spot than the hybrids having SP 571004-0 as the pollinator. However, since the average difference in resistance was not large, and since the epidemic was only moderate in intensity, it is felt that the Russian hybrids were handicapped only slightly.

These results do not indicate a general superiority of either of the Russian monogerm strains as pollinators for the American CMS monogerm material studied. However, the outstanding yield of roots and gross sucrose obtained from 2 hybrids involving Russian monogerm material and the CMS strain, SP 571702-01, is of special interest. This evidence of superior specific combining ability may merit further study, though the stability of the monogerm character in the Russian material --- particularly in Acc. 2199 --- is open to question.

Observational Test of Miscellaneous European and American Varieties

In 1960, several miscellaneous accessions were in an observational field test for the primary purpose of evaluating for leaf spot resistance. A brief description of the entries, together with the relative leaf spot damage, is given on pages 258 and 259.

Table 2.

OBSERVATIONAL TEST OF MISCELLANEOUS EUROPEAN AND AMERICAN MATERIAL

Leaf Spot Sprinkler Field, Hospital Farm, Fort Collins, Colorado

Experiment No. 8A, 1960

Description	Immed. Par. or Contrib. No.	F. C. Seed No.	Entry No.	Leaf Spot[a/] 9/13	Leaf Spot[a/] 9/21	Foliage Vigor[b/]	No. of Plots
US 401 (LS-BR res. ck.)	WC 5354	Acc. 2057	801	2.3	2.4	5.8	8
5481-0 (F.L. 801)	EL 1023	Acc. 2231	802	1.8	2.0	6.0	2
5481-0	WC 5214	Acc. 2191	803	2.0	2.3	6.0	2
Diploid monogerm (Poland) (Dr. Szota)	MonoIHAR	Acc. 2234	804	4.2	4.5	5.0	3
Light red hypo. (RR); Dr. Szota, Pol.; r. bolt. susc.	1956/59	Acc. 2235	805	3.0	3.8	4.7	3
Green hypo. (rr); Dr. Szota, Pol.; r. bolt. susc.	1956/59	Acc. 2236	806	3.2	3.5	5.0	3
Tetraploid (rrrr); Dr. Szota, Pol.	Tetra AJ_3C_2	Acc. 2237	807	2.5	2.5	6.3	3
Tetraploid (RRRR); Dr. Szota, Pol.	AJ_3 Tetra C_2	Acc. 2238	808	3.2	3.7	7.0	3
From Dr. Szota, Pol.; somewhat tol. to v. yel. in Pol.	Tetra PCR No.6	Acc. 2239	809	2.2	2.5	6.3	3
Com'l var.	GW 359-52R	Acc. 1359	810	2.4	2.7	5.5	6
Incr. of GW 359-52R	A56-3(Powers)	Acc. 2247	811	2.3	2.8	6.0	6
Incr. of Powers' "Sel. A54-1 Syn." (Sel. fr. GW 359-52R)	C817 (G.W.S.Co.)	Acc. 2232	812	2.3	2.8	5.8	6
F_2 from 2 rts. of US 201-B (CTR); segr. for aa; (=SL727)	SL 915	Acc. 2240	813	4.3	4.7	4.0	3
F_1, US 201-B (727 sel.) aa X 57109-0 etc.	SL 9401	Acc. 2241	814	2.8	3.3	5.0	3
Bien. sel. in F_2 fr. the cross, US 201 X CTR annual	SL 865	Acc. 2242	815	5.3	5.7	3.7	3
CT5 aa X CT9 A; "aa" segr. not expected	SL 932	Acc. 2244	816	3.3	3.5	4.3	3
CT5 aa X sibs; "aa" segr. expected; partial T.O.	SL 9450	Acc. 2245	817	4.0	3.8	4.0	3
do	SL 9452	Acc. 2246	818	5.0	5.0	3.3	3
SL 119 mm MS X SP 5481-0 MM		Acc. 2248	819	2.7	2.8	5.7	3
SL 119 mm MS X SP 5460-0 MM		Acc. 2249	820	2.7	3.0	5.7	3
SL 119 mm MS X SP 5713-0 MM		Acc. 2250	821	2.7	2.7	5.7	3
SL 119 mm MS X SP 5510-0 MM		Acc. 2251	822	2.3	2.5	5.3	3
SL 119 mm MS X SP 5834-0 mm		Acc. 2252	823	2.5	2.7	5.7	3
SL 122 mm MS X SP 5481-0 MM		Acc. 2253	824	2.0	2.3	5.7	3
SL 122 mm MS X SP 5460-0 MM		Acc. 2254	825	2.2	2.5	5.3	3
SL 122 mm MS X SP 5713-0 MM		Acc. 2255	826	2.8	3.2	5.0	3
SL 122 mm MS X 5510-0 MM		Acc. 2256	827	2.8	2.8	5.7	3
SL 122 mm MS X 5834-0 mm		Acc. 2257	828	2.8	2.8	5.3	3

Table 2 (cont.)

Experiment No. 8A, 1960 (cont)

Description	Immed. Par. or Contrib. No.	F. C. Seed No.	Entry No.	Leaf Spot a/ 9/13	Leaf Spot a/ 9/21	Foliage Vigor b/	No. of Plots
LS-BR res. MM	SP 5460-0	Acc. 2258	829	1.7	1.8	6.0	3
do	SP 5713-0	Acc. 2259	830	1.2	1.7	5.3	3
do	SP 5510-0	Acc. 2260	831	2.2	2.3	5.7	3
LS-BR res. mm	SP 5834-0	Acc. 2261	832	1.7	2.0	5.3	3
LS-BR res. mm	SP 5831-0	Acc. 2262	833	1.5	1.7	5.0	3
Sel. incr. of 5831-0 (LS-BR res. mm)	SP 5931-0	Acc. 2263	834	2.0	2.0	5.7	3
LS-BR res. MM; superior in S % and Gr. suc. y.	SP 5822-0	Acc. 2243	835	1.3	1.5	5.7	3
US 22/4 (CTR ck.)	SL 92	Acc. 1363	836	4.0	4.0	4.7	6
US 201 (LSR ck.)	501007-0	581001-0	837	0.9	0.9	6.2	5

a/ Leaf spot readings (J. A. Elder): 0 = no leaf spot; 10 = complete defoliation.

b/ Foliage vigor readings (9/13/60; J. A. Elder): Low no. = poor; high no. = strong.

Field plan:

Plots 2 rows X 12'; 2 to 8 replications as indicated. Artificial inoculation and frequent sprinkling were used to promote leaf spot development.

Remarks:

The leaf spot epidemic reached peak stage about September 20.

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PART X

DEVELOPMENT AND EVALUATION OF SUGAR BEET VARIETIES SUITABLE FOR THE GREAT LAKES REGION

Breeding to Combine Resistance to Leaf Spot and Black Root in High Quality Lines and Productive Varieties

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Evaluation of Miscellaneous Varieties

Foundation Project 26

Dewey Stewart
G. E. Coe
C. L. Schneider
J. O. Gaskill
H. W. Bockstahler
G. J. Hogaboam
H. L. Bissonnette
J. C. Overpeck

Cooperators conducting field tests:

Farmers & Manufacturers Beet Sugar Association
Buckeye Sugars, Inc.
Canada and Dominion Sugar Company, Ltd.
The Great Western Sugar Company
Menominee Sugar Company
Michigan Sugar Company
Monitor Sugar Division
Northern Ohio Sugar Company
Colorado Agricultural Experiment Station
Michigan Agricultural Experiment Station
New Mexico Agricultural Experiment Station

Developments and Evaluation of Basic Breeding Material and Varieties Suitable for the Great Lakes Region

The cooperative variety tests conducted in the Great Lakes Region in 1960 were planned primarily to appraise regional adaptation of experimental hybrids that were produced by the Farmers & Manufacturers Beet Sugar Association and to evaluate new breeding material arising in cooperative breeding research conducted at the Plant Industry Station, Beltsville, Maryland; Michigan Agricultural Experiment Station, East Lansing, Michigan; and elsewhere.

The experimental monogerm hybrids afforded an opportunity to compare the combining ability of two male-sterile monogerm lines, SLC 119MS and SLC 122MS, in hybridizations with four synthetic multigerm varieties and one monogerm variety. Each of these monogerm lines, SLC 119MS and SLC 122MS, occurred as the monogerm seed parent in five hybrids. SLC 119 was developed by V. F. Savitsky from the hybridization of US 216 and SLC 101 and selected for leaf spot resistance by J. O. Gaskill at Fort Collins. SLC 122 was developed by F. V. Owen from hybrids to seven lines carrying curly top resistance.

The synthetic multigerm varieties--SP 5460-0, SP 5481-0, SP 5510-0, and SP 5713-0, as well as the monogerm SP 5834-0, were used as pollen parents. The pollen parents carrying resistance to leaf spot and black root were developed largely through cooperative breeding programs conducted at the Plant Industry Station, where breeding research is conducted by G. E. Coe, and at East Lansing, Michigan, where field tests were conducted by G. J. Hogaboam and H. W. Bockstahler. The development of leaf spot and black root resistance in these varieties has been enhanced through greenhouse screening tests conducted by C. L. Schneider and through field tests conducted by H. L. Bissonnette in cooperation with the Minnesota Agricultural Experiment Station.

The multigerm pollinators are moderate to good in resistance to leaf spot and black root. SP 5481-0, under the designation of US 401, is being used as a commercial variety. The salient characters and a brief breeding history of these pollinators are given on pages 263 and 264. G. J. Hogaboam selected the experimental design (page 266) and supervised the analysis of variance in the nine tests summarized on page 267.

The regional performance of the hybrids, as indicated from average values given in the summary table, did not show a significant difference in sucrose percentage or in coefficient of apparent purity. The average number of plants per 100 feet of row showed good stands for all of the varieties, and differences between stand for the entries were not statistically significant at the 1-percent point. The hybrids showed significant difference in acre yield of roots, and this was reflected in significant differences in gross sugar per acre.

In the nine cooperative field tests summarized on page 267, the multigerm variety, SP 5481-0, which is being used in commercial plantings in the Great Lakes region under the designation of US 401, should be taken as a standard of comparisons of hybrid performances. It will be noted that the hybrids obtained from crossing the monogerm line SLC122MS with the multigerm pollinators, SP 5460-0, SP 5481-0, and SP 5510-0, did not differ significantly from the commercial multigerm variety, SP 5481-0, in acre yield of roots or gross sugar. Although not statistically significant, the hybrids in which SP 5460-0 and SP 5481-0 were used as the pollen parent with SLC122MS were slightly higher in sucrose percentage than the multigerm standard.

The two monogerm lines did not show equal combining ability when crossed with the five pollinators. It is evident that the hybrids having SLC122MS as monogerm seed parent were superior to those having SLC119MS as seed parent. Therefore, the summaries confirm that the combination SLC122MS X SP 5460-0, which is being used for the production of commercial monogerm hybrid seed, was a proper choice of parentage; and furthermore, that SLC122MS X SP 5481-0, the monogerm variety, would have given an acceptable monogerm hybrid.

Hybrids produced with the monogerm variety SP 5834-0 as pollinator were lower in root yield than those obtained with the multigerm pollinators. This demonstrates the difficulty that has been experienced in finding monogerm lines of high combining ability.

In addition to the tests summarized on page 267, tests were also conducted in Ohio by the Northern Ohio Sugar Company. Leaf spot exposure in these tests was more severe, which may explain the less favorable performances of the monogerm hybrids when compared with SP 5481-0. However, in these tests, monogerm hybrids SLC 122MS X SP 5460-0 and SLC 122MS X SP 5481-0 were the best. Attention is directed to the excellent performance of SP 5822-0 in the tests conducted by the Northern Ohio Sugar Company, and specifically to the high coefficient of thin juice purity.

Nursery tests were conducted at East Lansing and Merrill, Michigan, to evaluate new lines, synthetics, and breeder seed of new developments arising in the breeding research conducted by G. E. Coe and G. J. Hogaboam. The performances of the items, mostly monogerm, show that progress has been made in the development of improved monogerm breeding material. The root yield and sucrose percent of SP 59B18-0 was outstanding in both tests. Although SP 59B18-0 is multigerm, it may prove to be of special value as a pollinator in hybrid seed production.

Description of Varieties and Pollinators of Hybrids in 1960 Field Trials in Part X

SP 5460-0 - Seed increase of selected roots from a single open-pollinated multigerm progeny. This line has good leaf spot resistance and fair resistance to black root. It has performed well in certain hybrid combinations.

SP 5481-0 - Seed increase of selected roots from 12 open-pollinated multigerm progenies out of SP 53AB1. This variety has slightly less resistance to leaf spot than SP 5460-0 but better resistance to leaf spot and black root than U.S. 401.

SP 5510-0 - A synthetic multigerm variety produced by increasing the selfed seeds from 5 plants which had good open-pollinated progenies in the nursery trial. This variety has better resistance to leaf spot and black root than U.S. 401, and also slightly better gross sugar yield.

SP 5713-0 - Synthetic multigerm variety produced by a seed increase of clones from 4 selected plants out of SP 5460-0 plus 1 clone from another multigerm source. This variety has better leaf spot resistance than SP 5460-0, but it is somewhat lower in yield.

SP 5822-0 - A multigerm synthetic variety produced by a seed increase from 7 clones. This variety has good resistance to leaf spot and black root; good in sugar percentage and purity. It is lower in tonnage than U.S. 401.

SP 5834-0 - Monogerm variety - A seed increase of stecklings of the best progenies in the 1957 nursery tests. It has better leaf spot resistance than U.S. 401.

SP 5838-0 - Monogerm variety - Produced from 5 clones of plants whose open-pollinated progenies had the best tonnage in the nursery tests.

SP 5931-0 - Monogerm variety - A seed increase of stecklings of progeny-tested plants selected from SP 5831-0, a seed increase of selected roots from the backcrossing program.

SP 5932-01 - Monogerm variety - A seed increase of stecklings of 13 progenies of plants selected from SP 5834-0.

SP 5932-02 - Monogerm variety - A seed increase of stecklings of 7 progenies of plants selected from SP 5834-0.

SP 5933-0 - Monogerm variety - A seed increase of stecklings of 5 progenies of plants selected from SP 5834-0.

SP 5934-01 - Monogerm variety - Recovered from backcrossing program. Stems from "O" type monogerm, SP 5520-0.

SP 5935-0 - Monogerm variety - A seed increase of unselected monogerm plants recovered from backcrossing program.

SP 5937-0 - Monogerm variety - Produced from 8 clones of roots whose open-pollinated progenies had reasonable yield and best purity in nursery tests.

SP 5941-01 - SP 5834-0 mm X SP 5481-0 MM - Plants of these two varieties were grown in alternate hills down the row in an isolation seed plot. Seed was harvested from monogerm plants only.

SP 5942-01 - SP 5834-0 mm X SP 5460-0 MM - Plants of these two varieties were grown in alternate hills down the row in an isolation seed plot. Seed was harvested from monogerm plants only.

SP 59500-01 - SP 5720-01 W.A. mm X selected MM plants of the best breeding lines in black root and leaf spot resistance. Seed was harvested from mm W.A. plants only.

SP 59693-01 - SP 5834-0 mm X SP 5510 MM - Plants of these two varieties were grown in alternate hills down the row in an isolation seed plot. Seed was harvested from the monogerm plants only.

Leaf Spot Readings at Plant Industry Station on Varieties Included in Latin Square Tests Summarized on page 267 and in Other Tests on pages 292-299.

Variety	Leaf Spot[1/]	Variety	Leaf Spot
SP 5460-0	4.2	SL 119MS X SP 5460-0	4.7
SP 5481-0	4.2	SL 119MS X SP 5481-0	4.7
SP 5510-0	4.4	SL 119MS X SP 5510-0	4.8
SP 5713-0	3.2	SL 119MS X SP 5713-0	4.4
SP 5822-0	3.0	SL 119MS X SP 5834-0	4.8
SP 5834-0	4.4	SL 122MS X SP 5460-0	5.0
SP 5931-0	4.2	SL 122MS X SP 5481-0	5.0
SP 5945-0	4.3	SL 122MS X SP 5510-0	5.2
SP 59300-0	4.0	SL 122MS X SP 5713-0	4.9
US 201	2.0	SL 122MS X SP 5834-0	5.2
US 401	4.8	SL 122MS Line	5.7
Acc.1327 (Syn. Ch.)	7.0		

1/ Disease readings given as averages of single-row readings from two 4-row plots. Readings made by G. E. Coe., August 12, 1960.

Scale of readings: 1 = spots but no blight; 10 = destruction of foliage, except for whorls of small leaves in center of crown.

Latin Square Set design used to test 12 varieties with 6 replications.

Design 1. of 10 designs available at East Lansing.

	col. 1		:	col. 2		:	col. 3		:	col. 4		:	col. 5		:	col. 6	
row 6.	10	5	:	4	12	:	9	2	:	6	11	:	8	7	:	3	1
row 5.	7	3	:	9	1	:	10	8	:	5	12	:	6	11	:	4	2
row 4.	2	8	:	11	6	:	1	3	:	4	7	:	10	9	:	12	5
row 3.	6	9	:	5	2	:	7	4	:	1	8	:	3	12	:	10	11
row 2.	4	1	:	8	7	:	11	12	:	3	10	:	5	2	:	6	9
row 1.	12	11	:	10	3	:	5	6	:	9	2	:	4	1	:	8	7

Analysis of Variance

Source	d.f.
Row	5
Column	5
Variety	11
Error	50
Total	71

The latin square sets are formed by using one 6 x 6 latin square to assign 6 of the 12 entry numbers and another 6 x 6 latin square to assign the other 6 entry numbers. This design has all 12 varieties in each row and all 12 varieties in each column. It differs from a regular latin square in that each column is 2 plots wide instead of 1 plot wide, otherwise the analysis is the same.

Year: 1960

Summary of Latin Square Sets Experiments conducted by U.S.D.A., F.&M. Beet Sugar Association and member Companies. Nine experiments analyzed and tested with Variety X Location interaction.

Locations: Chatham and St. Mary's, Ontario; Croswell, Essexville, LaPorte, Sebewaing, and East Lansing, Michigan; Pandora, Ohio; Chilton, Wisconsin.

Variety & Description	Acre-Yield		Sucrose	Purity	Beets per 100' of row
	Gross Sugar	Roots			
	Pounds	Tons	Percent	Percent	Number
SL 122 ms X SP 5460-0	5512	16.33	16.88	87.56	90
SL 122 ms X SP 5481-0	5430	16.07	16.83	87.74	88
SL 122 ms X SP 5713-0	5294	15.69	16.87	87.34	92
SL 122 ms X SP 5510-0	5510	16.29	16.91	87.52	92
SL 122 ms X SP 5834-0	4934	14.59	16.80	87.26	89
SL 119 ms X SP 5460-0	5338	15.79	16.93	87.10	90
SL 119 ms X SP 5481-0	5297	15.73	16.82	87.21	90
SL 119 ms X SP 5713-0	5184	15.22	16.86	87.65	89
SL 119 ms X SP 5510-0	5395	16.09	16.79	87.61	91
SL 119 ms X SP 5834-0	5048	14.99	16.66	87.41	90
SP 5931-0	5203	15.60	16.66	87.02	87
SP 5481-0	5518	16.80	16.49	87.27	86
General Mean	5305	15.77	16.79	87.39	90
S. E. var mean	92.7	.2634	.1359	.3092	1.3
S.E. var.Mean as % Gen.M.	1.75	1.67	0.81	0.35	1.45
Diff. for sig. (19:1)	260	.74	NS	NS	4
(99:1)	345	.98			NS

Variety X Location Analysis

Variance Table

Source of Variation	D/F	Mean Squares				
		Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between Locations	8	21,919,546	148.2302	51.6344	87.4852	635
Between Varieties	11	282,948	3.1967	.1500	.3636	35
Varieties X Locations	88	77,324	0.6236	.1648	.6688	15
Total	107					
Calculated F value	11/88	3.66**	5.13**	NS	NS	2.27*

AGRONOMIC EVALUATION TEST - 1960

Conducted by: M.R. Berrett.

Location: Harold Gremel farm, Sebewaing, Michigan.

Cooperation: F. & M. Beet Sugar Association, Michigan Sugar Co.

Date of Planting: April 29, 1960.

Date of Harvest: October 28, 1960.

Experimental Design: 12 var., 6 repl., Latin Square set, Design #2.

Size of Plots: 6 rows x 28 feet, 28 inches between rows.

Harvested Area per Plot for Root Yield: 4 rows x 26 feet.

Samples for Sucrose Determination: 2 samples of 10 beets each, selected at random.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1957 - Pasture; 1958 - Corn 250# 5-20-20; 1959 - Beans 250# 6-24-12 with Magnesium.

Fertilization of Beet Crop: 700# 6-24-12 with Borax and Magnesium.

Black Root Exposure: None.

Leaf Spot Exposure: Slight.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Wet seedbed. Generally good growing conditions although little short of rainfall during August and September.

Realiability of Test: Good.

Cooperator: F. & M. Beet Sugar Association, Michigan Sugar Co. Year: 1960

Location: Harold Gremel farm, Sebewaing, Michigan Expt: 2

"Latin Square Set" Experiment -- 2 - 6 X 6 LSQ to test 12 var. with 6 repl.

(Results given as 6 plot averages)

Variety and Description	Acre-Yield Gross Sugar	Acre-Yield Roots	Sucrose	Purity	Beets per 100' of row
	Pounds	Tons	Percent	Percent	Number
SL 122 ms X SP 5460-0	7,165	18.94	18.93 1	89.31	91
SL 122 ms X SP 5481-0	7,192	19.36	18.56	89.36	89
SL 122 ms X SP 5713-0	7,341	19.18	19.18 1	88.68	94
SL 122 ms X SP 5510-0	7,703 1	20.51 1	18.82	89.43	89
SL 122 ms X SP 5834-0	7,132	19.12	18.67	89.07	88
SL 119 ms X SP 5460-0	7,246	19.28	18.78	88.89	86
SL 119 ms X SP 5481-0	7,464 2	19.82 3	18.84	89.41	87
SL 119 ms X SP 5713-0	7,357	19.92 2	18.50	89.61	88
SL 119 ms X SP 5510-0	7,462 3	19.77 4	18.88	88.78	90
SL 119 ms X SP 5834-0	7,282	19.39	18.83	90.15	88
SP 5931-0	7,421 4	19.64 5	18.92 3	89.62 2	86
SP 5481-0	7,313	19.97	18.34	89.59	87
General Mean	7,340	19.57	18.77	89.32	88
S.E. Var. Mean	244.8	.7253	.2544	.4883	3.2
S.E. Var. Mean as % Gen.Mean	3.34	3.71	1.36	0.55	3.64
Diff. for Sig. (odds 19:1)	NS	NS	NS	NS	NS

Latin Square Analysis — Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between rows	5	1,595,128	10.3241	.8031	4.6157	40
Between columns	5	649,622	6.2236	.4195	2.5227	23
Between varieties	11	151,362	1.1882	.3079	1.4227	32
Remainder - Error	50	359,836	3.1574	.3884	1.4310	60
Total	71					
Calculated F. value	11/50	NS	NS	NS	NS	NS

AGRONOMIC EVALUATION TEST - 1960

Conducted by: M. R. Berrett.

Location: Reed Gordon farm, Croswell, Michigan.

Cooperation: F. & M. Beet Sugar Association, Michigan Sugar Co.

Date of Planting: May 4, 1960.

Date of Harvest: October 25, 1960.

Experimental Design: 12 var., 6 repl., Latin Square set, Design #3.

Size of Plots: 6 rows x 28 feet, 28 inches between rows.

Harvested Area per Plot for Root Yield: 4 rows x 26 feet.

Samples for Sucrose Determination: 2 samples of 10 beets each, selected at random.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1957 - Oats, 275# 5-20-10; 1958 - Wheat-seeded 250# 6-24-12 & 150# 12-12-12 in spring; 1959 - Hay 2nd crop plowed down, manure 10 ton/acre.

Fertilization of Beet Crop: 500# 5-20-10.

Black Root Exposure: None.

Leaf Spot Exposure: None.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Moist seedbed. Generally good growing conditions throughout growing season.

Reliability of Test: Good.

Cooperator: F. & M. Beet Sugar Association, Michigan Sugar Co. Year: 1960

Location: Reed Gordon farm, Croswell, Michigan Expt: 3

"Latin Square Set" Experiment -- 2 - 6 X 6 LSQ to test 12 var. with 6 repl.

(Results given as 6 plot averages)

Variety and Description	Acre-Yield Gross Sugar	Acre-Yield Roots	Sucrose	Purity	Beets per 100' of row
	Pounds	Tons	Percent	Percent	Number
SL 122 ms X SP 5460-0	6,880 2	17.79	19.37	89.93	90
SL 122 ms X SP 5481-0	6,891 1	17.82	19.33	90.40	88
SL 122 ms X SP 5713-0	6,380 11	16.74	19.06	90.32	93
SL 122 ms X SP 5510-0	6,767 3	18.04	18.77	88.63	92
SL 122 ms X SP 5834-0	6,712 4	17.25	19.48	89.95	93
SL 119 ms X SP 5460-0	6,518 9	17.13	19.11	89.25	91
SL 119 ms X SP 5481-0	6,712 4	17.92	18.75	89.44	92
SL 119 ms X SP 5713-0	6,641 7	17.40	19.11	89.65	95
SL 119 ms X SP 5510-0	6,678 6	17.61	19.01	89.36	94
SL 119 ms X SP 5834-0	6,285 12	16.56	18.99	89.92	87
SP 5931-0	6,509 10	17.38	18.79	90.13	89
SP 5481-0	6,569 8	18.01 1	18.28	89.21	79
General Mean	6,629	17.47	19.00	89.68	90
S.E. Var. Mean	386.1	1.0219	.1930	.3134	5.4
S.E. Var. Mean as % Gen.Mean	5.91	5.93	1.02	0.35	6.07
Diff. for Sig. (odds 19:1)	NS	NS	0.55	0.89	NS

Latin Square Analysis — Variance Table

Source of Variation	D/F	Mean Squares Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between rows	5	1,447,128	15.5443	1.1070	.7713	121
Between columns	5	2,663,786	21.7597	.8886	1.2786	433
Between varieties	11	596,379	4.9092	.6125	1.5277	212
Remainder - Error	50	894,489	6.2675	.2236	.5894	173
Total	71					
Calculated F. value	11/50	NS	NS	2.74**	2.59*	NS

AGRONOMIC EVALUATION TEST - 1960

Conducted by: M. R. Berrett, G. E. Nichol.

Location: Omer Foret farm, Essexville, Michigan.

Cooperation: F. & M. Beet Sugar Association, Monitor Sugar Division.

Date of Planting: May 25, 1960.

Date of Harvest: October 7, 1960.

Experimental Design: 12 var., 6 repl., Latin Square set, Design #8.

Size of Plots: 6 rows x 28 feet, 28 inches between rows.

Harvested Area per Plot for Root Yield: 4 rows x 26 feet.

Samples for Sucrose Determination: 2 samples of 10 beets each from each plot selected at random.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1957 - Beets; 1958 - Beans; 1959 - Wheat, seeded.

Fertilization of Beet Crop: 600# 5-20-20.

Black Root Exposure: Slight.

Leaf Spot Exposure: None.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Moist seedbed. Inadequate rainfall during August and September.

Reliability of Test: Fair.

Cooperator: F. & M. Beet Sugar Association, Monitor Sugar Division Year: 1960

Location: Omer Foret farm, Essexville, Michigan Expt: 8

"Latin Square Set" Experiment -- 2 - 6 X 6 LSQ to test 12 var. with 6 repl.

(Results given as 6 plot averages)

Variety and Description	Acre-Yield Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
	Pounds	Tons	Percent	Percent	Number
SL 122 ms X SP 5460-0	5,859	18.40	15.89	83.64	85
SL 122 ms X SP 5481-0	5,863	18.13	16.17	84.29	84
SL 122 ms X SP 5713-0	5,535	17.59	15.73	83.03	91
SL 122 ms X SP 5510-0	5,785	18.59	15.55	83.20	87
SL 122 ms X SP 5834-0	5,118	16.11	15.87	83.20	86
SL 119 ms X SP 5460-0	5,408	17.85	15.15	83.16	88
SL 119 ms X SP 5481-0	5,498	17.62	15.60	83.38	87
SL 119 ms X SP 5713-0	5,373	16.93	15.87	84.98	85
SL 119 ms X SP 5510-0	5,520	17.92	15.41	83.81	84
SL 119 ms X SP 5834-0	5,454	17.62	15.48	83.50	88
SP 5931-0	5,399	17.80	15.17	84.07	79
SP 5481-0	5,513	18.67	14.75	83.05	78
General Mean	5,527	17.77	15.55	83.61	85
S.E. Var. Mean	125.4	.3765	.2190	.5983	2.5
S.E. Var. Mean as % Gen.Mean	2.27	2.12	1.41	0.72	2.94
Diff. for Sig. (odds 19:1)	356	1.07	0.62	NS	7

Latin Square Analysis — Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between rows	5	357,199	1.4827	.8833	3.1581	69
Between columns	5	1,178,257	5.9289	1.0337	2.2161	104
Between varieties	11	282,517	3.0475	.9372	1.9131	86
Remainder - Error	50	94,434	.8508	.2878	2.1487	38
Total	71					
Calculated F. value	11/50	2.99**	3.58**	3.26**	NS	2.32*

AGRONOMIC EVALUATION TEST - 1960

Conducted by: M. R. Berrett, G. E. Nichol.

Location: Ross Thayer farm, LaPorte, Michigan.

Cooperation: F. & M. Beet Sugar Association, Monitor Sugar Division.

Date of Planting: May 21, 1960.

Date of Harvest: October 13, 1960.

Experimental Design: 12 var., 6 repl., Latin Square set, Design #6.

Size of Plots: 6 rows x 28 feet, 28 inches between rows.

Harvested Area per Plot for Root Yield: 4 rows x 26 feet.

Samples for Sucrose Determination: 2 samples of 10 beets each, selected at random.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1957 - Wheat, 250# 5-20-20 & 250# 12-12-12; 1958 - Soil Bank; 1959 - Corn 300# 5-20-20 & 50# Ammonia.

Fertilization of Beet Crop: 400# 6-24-12 & 50# Ammonia.

Black Root Exposure: None.

Leaf Spot Exposure: None.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Moist seedbed. Generally good growing conditions although little short of rainfall during August and September.

Realiability of Test: Fair.

Cooperator: F. & M. Beet Sugar Association, Monitor Sugar Division Year: 1960

Location: Ross Thayer farm, LaPorte, Michigan Expt: 6

"Latin Square Set" Experiment -- 2 - 6 X 6 LSQ to test 12 var. with 6 repl.

(Results given as 6 plot averages)

Variety and Description	Acre-Yield Gross Sugar	Acre-Yield Roots	Sucrose	Purity	Beets per 100' of row
	Pounds	Tons	Percent	Percent	Number
SL 122 ms X SP 5460-0	5,546	14.39	19.26	89.31	86
SL 122 ms X SP 5481-0	5,102	13.43	19.04	88.68	84
SL 122 ms X SP 5713-0	5,138	13.10	19.60	90.00	93
SL 122 ms X SP 5510-0	5,612	14.20	19.78	89.96	95
SL 122 ms X SP 5834-0	5,096	12.88	19.78	89.51	91
SL 119 ms X SP 5460-0	5,475	13.99	19.59	89.73	92
SL 119 ms X SP 5481-0	4,992	13.16	18.97	89.45	83
SL 119 ms X SP 5713-0	5,436	13.73	19.80	89.97	89
SL 119 ms X SP 5510-0	5,338	13.76	19.43	89.85	93
SL 119 ms X SP 5834-0	5,049	13.03	19.37	90.17	93
SP 5931-0	4,738 12	12.55 12	18.82	89.18	83
SP 5481-0	5,746	15.27	18.83	89.20	81
General Mean	5,272	13.62	19.36	89.58	88
S.E. Var. Mean	231.8	.5702	.2738	.4084	.4090
S.E. Var. Mean as % Gen.Mean	4.40	4.19	1.41	0.46	0.46
Diff. for Sig. (odds 19:1)	NS	NS	NS	NS	NS

Latin Square Analysis — Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between rows	5	212,495	2.4425	.4983	2.6404	150
Between columns	5	545,032	3.5914	.5881	.0841	227
Between varieties	11	533,756	3.4991	.8484	.9614	145
Remainder - Error	50	322,320	1.9514	.4498	1.0011	100
Total	71					
Calculated F. value	11/50	NS	NS	NS	NS	NS

AGRONOMIC EVALUATION TEST - 1960

Conducted by: M. R. Berrett.

Location: Louis Risser farm, Pandora, Ohio.

Cooperation: F. & M. Beet Sugar Association, Buckeye Sugars Inc.

Date of Planting: April 25, 1960.

Date of Harvest: October 4, 1960.

Experimental Design: 12 var., 6 repl., Latin Square set, Design #1.

Size of Plots: 6 rows x 28 feet, 28 inches between rows.

Harvested Area per Plot for Root Yield: 4 rows x 26 feet.

Samples for Sucrose Determination: 2 samples of 10 beets each, selected at random.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1957 - Hay; 1958 - Beets, 400# Muriate of potash & 100# N plowed down 200# 11-48-0 planting time; 1959 - 500# Muriate of potash plowed down - 300# 8-24-0 planting time plus 140# N sidedressed.

Fertilization of Beet Crop: 400# 6-18-6 & Boron - 62# N per acre plowed down.

Black Root Exposure: None.

Leaf Spot Exposure: Moderate.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Dry seedbed. Inadequate rainfall during August and September.

Reliability of Test: Good.

Cooperator: F. & M. Beet Sugar Association, Buckeye Sugars, Inc. Year: 1960

Location: Louis Risser Farm, Pandora, Ohio Expt: 1

"Latin Square Set" Experiment -- 2 - 6 X 6 LSQ to test 12 var. with 6 repl.

(Results given as 6 plot averages)

Variety and Description	Acre-Yield Gross Sugar	Acre-Yield Roots	Sucrose	Purity	Beets per 100' of row
	Pounds	Tons	Percent	Percent	Number
SL 122 ms X SP 5460-0	5,823	19.40	15.22	81.83	94
SL 122 ms X SP 5481-0	5,997	18.64	16.38	83.21	90
SL 122 ms X SP 5713-0	5,690	18.11	15.91	82.20	90
SL 122 ms X SP 5510-0	5,422	17.08	16.05	82.52	93
SL 122 ms X SP 5834-0	4,402	14.24	15.68	81.52	91
SL 119 ms X SP 5460-0	5,515	17.68	15.72	81.42	86
SL 119 ms X SP 5481-0	5,675	18.55	15.48	82.50	94
SL 119 ms X SP 5713-0	5,331	16.78	15.99	82.46	87
SL 119 ms X SP 5510-0	5,745	18.55	15.68	81.99	91
SL 119 ms X SP 5834-0	4,934	15.63	15.91	83.07	92
SP 5931-0	5,386	16.44	16.64	82.26	95
SP 5481-0	6,151	18.88	16.59	83.78	93
General Mean	5,506	17.50	15.94	82.40	91
S.E. Var. Mean	219.8	.7468	.2596	.5520	3.3
S.E. Var. Mean as % Gen.Mean	3.99	4.27	1.63	0.67	3.63
Diff. for Sig. (odds 19:1)	624	2.12	0.74	NS	NS

Latin Square Analysis — Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between rows	5	1,553,375	14.5037	1.5923	7.0109	224
Between columns	5	2,462,236	94.6777	23.4967	4.6831	232
Between varieties	11	1,350,562	13.8827	1.1281	3.2211	46
Remainder - Error	50	289,994	3.3474	.4044	1.8283	63
Total	71					
Calculated F. value	11/50	4.66**	4.15**	2.79**	NS	NS

AGRONOMIC EVALUATION TEST - 1960

Conducted by: M. R. Berrett.

Location: George Schwarz farm, Chilton, Wisconsin.

Cooperation: F. & M. Beet Sugar Association, Menominee Sugar Co.

Date of Planting: May 25, 1960.

Date of Harvest: October 19, 1960.

Experimental Design: 12 var., 6 repl., Latin Square set, Design #9.

Size of Plots: 6 rows x 28 feet, 28 inches between rows.

Harvested Area per Plot for Root Yield: 4 rows x 26 feet.

Samples for Sucrose Determination: 2 samples of 10 beets each, selected at random.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1957 - Sugar Beets 200# 4-16-16 & 8% Borax; 1958 - Wheat; 1959 - Oats.

Fertilization of Beet Crop: 210# 4-16-16 & 8% Borax.

Black Root Exposure: None.

Leaf Spot Exposure: Slight.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Moist seedbed. Above normal rainfall throughout growing season.

Reliability of Test: Excellent.

Cooperator: F. & M. Beet Sugar Association, Menominee Sugar Co. Year: 1960

Location: George Schwarz, Chilton, Wisconsin Expt: 9

"Latin Square Set" Experiment -- 2 - 6 X 6 LSQ to test 12 var. with 6 repl.

(Results given as 6 plot averages)

Variety and Description	Acre-Yield: Gross Sugar	Acre-Yield: Roots	Sucrose	Purity	Beets per 100' of row
	Pounds	Tons	Percent	Percent	Number
SL 122 ms X SP 5460-0	5,095 2	14.84	17.16	89.78	99
SL 122 ms X SP 5481-0	4,992 5	14.29	17.47	89.70	95
SL 122 ms X SP 5713-0	4,782	13.75	17.43	89.07	97
SL 122 ms X SP 5510-0	5,210 1	15.17	17.17	90.12	106
SL 122 ms X SP 5834-0	4,300	12.52	17.18	89.47	92
SL 119 ms X SP 5460-0	4,895 6	13.88	17.64	89.36	101
SL 119 ms X SP 5481-0	4,485	12.73	17.62	90.31	92
SL 119 ms X SP 5713-0	4,762	13.43	17.72	90.11	94
SL 119 ms X SP 5510-0	4,661	13.43	17.36	90.42	95
SL 119 ms X SP 5834-0	5,093 3	14.57	17.52	90.50	101
SP 5931-0	4,857 7	13.96	17.38	89.19	87
SP 5481-0	5,044 4	15.15	16.68	88.34	83
General Mean	4,848	13.98	17.36	89.69	95
S.E. Var. Mean	176.0	.4904	.1611	.5382	3.1
S.E. Var. Mean as % Gen.Mean	3.63	3.51	0.93	0.60	3.26
Diff. for Sig. (odds 19:1)	500	1.39	.46	NS	9

Latin Square Analysis Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between rows	5	2,520,857	22.9170	.1105	1.9486	440
Between columns	5	532,429	4.6203	.4433	1.5072	50
Between varieties	11	431,662	4.5091	.4409	2.6860	246
Remainder-Error	50	185,815	1.4431	.1558	1.7383	59
Total	71					
Calculated F. value	11/50	2.32*	3.12**	2.83**	NS	4.17**

AGRONOMIC EVALUATION TEST- 1960

Conducted by : C. E. Broadwell.

Location : C. & D. Sugar Co. Ltd. Chatham Front Office Field.

Cooperation : Canada & Dominion Sugar Co. Ltd.

Date of Planting: May 5, 1960

Date of Harvest : October 10, 1960

Experimental Design : 12 var., 6 repl., Latin Square Set, Design # 4.

Size of Plots : 6 rows x 28 feet, 24" between rows, planted with Planet Jr.

Harvested Area per plot for Root Yield : 4 rows x 28 feet, hand topped.

Samples for Sucrose Determination : Two samples of 10 beets each from each plot, selected at random.

Stand Counts : Harvested beets counted when weighed.

Recent Field History : Peas.

Fertilization of Beet Crop : 500 # 10-10-10 broadcast and disced in prior to planting.

Black Root Exposure : None.

Leaf Spot Exposure : None.

Other Diseases and Pests : None.

Soil and Seasonal Conditions : Wet in June, dry harvest.

Reliability of Test : Good.

Cooperator: C. & D. Sugar Co., F. & M. Beet Sugar Association Year: 1960

Location: C. & D. Experimental farm, Chatham, Ontario Expt: 4

"Latin Square Set" Experiment -- 2 - 6 X 6 LSQ to test 12 var. with 6 repl.

(Results given as 6 plot averages)

Variety and Description	Acre-Yield Gross Sugar	Acre-Yield Roots	Sucrose	Purity	Beets per 100' of row
	Pounds	Tons	Percent	Percent	Number
SL 122 ms X SP 5460-0	6,168 6	20.14	15.30		101
SL 122 ms X SP 5481-0	6,411 1	21.18	15.13		107
SL 122 ms X SP 5713-0	6,043 7	20.03	15.09		106
SL 122 ms X SP 5510-0	6,347 2	21.03	15.09		105
SL 122 ms X SP 5834-0	5,404 12	17.96	15.04		102
SL 119 ms X SP 5460-0	5,997 8	19.80	15.08		100
SL 119 ms X SP 5481-0	6,181 4	20.14	15.33		107
SL 119 ms X SP 5713-0	5,724 11	18.86	15.13		105
SL 119 ms X SP 5510-0	6,181 4	20.40	15.14		110
SL 119 ms X SP 5734-0	5,990 9	19.56	15.30		106
SP 5931-0	5,915 10	19.82	14.93		106
SP 5481-0	6,236 3	21.55	14.45		105
General Mean	6,050	20.04	15.09		105
S.E. Var. Mean	203.0	.5496	.2090		2.8
S.E. Var. Mean as % Gen.Mean	3.36	2.74	1.39		2.67
Diff. for Sig. (odds 19:1)	NS	1.56	NS		NS

Latin Square Analysis Variance Table

Source of Variation	D/F	Mean Squares Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between rows	5	543,676	4.4705	.4080		54
Between columns	5	1,397,471	12.6328	.4685		158
Between varieties	11	463,621	5.8678	.3302		49
Remainder - Error	50	247,239	1.8132	.2622		47
Total	71					
Calculated F. value	11/50	NS	3.24**	NS		NS

AGRONOMIC EVALUATION TEST - 1960

Conducted by: C. E. Broadwell.

Location: Jim & Gerald Bryan, St. Mary's, Ontario.

Cooperation: Canada & Dominion Sugar Co. Ltd.

Date of Planting: May 19, 1960.

Date of Harvest: October 17, 1960.

Experimental Design: 12 var., 6 repl., Latin Square set, Design #5.

Size of Plots: 28 feet long, 24 inch rows, 6 row plots, planted with Planet Jr.

Harvested Area per Plot for Root Yield: 4 center rows x 28 feet, hand topped.

Samples for Sucrose Determination: 2 samples of 10 beets each from each plot selected at random.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: Oats.

Fertilization of Beet Crop: 300 lbs. 4-24-20 banded when planted.

Black Root Exposure: None.

Leaf Spot Exposure: None.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Dry.

Reliability of Test: Fair (considering very dry conditions all growing season.

Cooperator: C. & D. Sugar Co., F. & M. Beet Sugar Association Year: 1960

Location: Jim & Gerald Bryan, St. Mary's, Ontario Expt: 5

"Latin Square Set" Experiment -- 2 - 6 X 6 LSQ to test 12 var. with 6 repl.

(Results given as 6 plot averages)

Variety and Description	Acre-Yield: Gross Sugar	Acre-Yield: Roots	Sucrose	Purity	Beets per 100' of row
	Pounds	Tons	Percent	Percent	Number
SL 122 ms X SP 5460-0	3,528 1	10.34	17.08		82
SL 122 ms X SP 5481-0	3,331 4	9.72	17.11		82
SL 122 ms X SP 5713-0	3,501 2	10.23	17.13		84
SL 122 ms X SP 5510-0	3,024 12	8.93	16.95		82
SL 122 ms X SP 5834-0	3,333 4	9.72	17.14		85
SL 119 ms X SP 5460-0	3,318 6	9.72	17.07		87
SL 119 ms X SP 5481-0	3,201 11	9.35	17.11		86
SL 119 ms X SP 5713-0	3,033 10	8.85	17.15		84
SL 119 ms X SP 5510-0	3,241 9	9.45	17.18		87
SL 119 ms X SP 5834-0	3,259 8	9.56	17.07		83
SP 5931-0	3,483 3	10.18	17.10		83
SP 5481-0	3,274 7	9.53	17.18		90
General Mean	3,294	9.63	17.10		84
S.E. Var. Mean	171.7	.4949	.0888		3.6
S.E. Var. Mean as % Gen.Mean	5.21	5.14	0.52		4.29
Diff. for Sig. (odds 19:1):	NS	NS	NS		NS

Latin Square Analysis — Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between rows	5	1,064,533	10.3849	.1585		58
Between columns	5	1,033,943	8.4183	.1595		58
Between varieties	11	158,738	1.2986	.0506		39
Remainder - Error	50	177,009	1.4699	.0473		76
Total	71					
Calculated F. value	11/50	NS	NS	NS		NS

AGRONOMIC EVALUATION TEST- 1960

Conducted by: G. J. Hogaboam, H. W. Bockstahler.

Location: M. S. U. farm, East Lansing, Michigan, North Nursery.

Cooperation: Michigan Agricultural Experiment Sta·tion- Farm Crops Dept.

Date of Planting : May 25, 1960. Pre-emergence spray, TCA & Endothal,May 27.

Date of Harvest : October 18, 1960. Machine harvested.

Experimental Design : Latin Square Set, Design # 10. 12 vars., 6 repls.

Size of Plots : 8 rows x 20 feet. 28" between rows.

Harvested Area per plot for Root Yield : 6 rows x 20 feet, machine topped.

Samples for Sucrose Determination : Two samples of 10 beets each from each plot selected at random from piles.

Stand Counts : Harvested beets counted when weighed.

Recent Field History : Continuous beets (agronomic evaluation tests) since 1958. Each year 1000# 5-20-20 plowed down.

Fertilization of Beet Crop: 1000# 5-20-20 plowed down.

Black Root Exposure : Moderate. Infected sorghum seed inoculum applied with beet seed at planting.

Leaf Spot Exposure : Moderate burning over field by mid September. Powdered beet leaf inoculum applied with a John Bean Row Crop sprayer July 29.

Other Diseases and Pests: Small amount of mosaic and Savoy appeared late in season.

Soil and Seasonal Conditions : Minimum tillage (plow-plant) used. Field was plowed slightly wetter than desirable. Adequate rainfall during growing season. Light frost touched leaves morning of Oct. 1. Blackened leaves in irregular areas throughout the field. Probably lowered the sugars.

Reliability of Test: Good. However, frost injury may have made sucrose data less reliable.

Cooperator: Michigan Agricultural Expt. Station- Farm Crops Dept. Year: 1960

Location: East Lansing, Michigan, M.S.U. Farm, North Nursery. Expt: 10

"Latin Square Set" Experiment -- 2 - 6 X 6 LSQ to test 12 var. with 6 repl.

(Results given as 6 plot averages)

Variety and Description	Acre-Yield Gross Sugar	Acre-Yield Roots	Sucrose	Purity	Beets per 100' of row
	Pounds	Tons	Percent	Percent	Number
SL 122 ms X SP 5460-0	3,550 5	12.85	13.80	89.14	80
SL 122 ms X SP 5481-0	3,099 9	12.08	12.38	88.56	79
SL 122 ms X SP 5713-0	3,236 7	12.56	12.73	88.10	81
SL 122 ms X SP 5510-0	3,728 2	13.16	14.06	88.83	80
SL 122 ms X SP 5834-0	2,912 11	11.53	12.43	88.12	81
SL 119 ms X SP 5460-0	3,672 4	12.81	14.25	87.90	80
SL 119 ms X SP 5481-0	3,470 6	12.30	13.70	86.06	81
SL 119 ms X SP 5713-0	2,999 10	11.14	13.38	86.83	77
SL 119 ms X SP 5510-0	3,729 2	13.96	13.13	89.12	85
SL 119 ms X SP 5834-0	2,095 12	9.17	11.51	84.62	72
SP 5931-0	3,118 8	12.71	12.20	84.76	76
SP 5481-0	3,825 1	14.21	13.32	87.76	81
General Mean	3,286	12.37	13.07	87.48	79
S.E. Var. Mean	347.5	.6744	.8952	.7982	3.8
S.E. Var. Mean as % Gen.Mean	10.58	5.45	6.85	0.91	4.81
Diff. for Sig. (odds 19:1)	987	1.92	NS	2.27	NS

Latin Square Analysis — Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between rows	5	1,631,819	14.5511	11.1448	12.4168	465
Between columns	5	3,166,222	11.4703	23.1520	6.5060	287
Between varieties	11	1,441,046	10.7858	4.1849	14.7988	63
Remainder - Error	50	724,515	2.7297	4.8098	3.8233	88
Total	71					
Calculated F. value	11/50	1.99*	3.95**	NS	3.87**	NS

AGRONOMIC EVALUATION TEST- 1960

Conducted by : G. J. Hogaboam, H. W. Bockstahler.

Location : M. S. U. farm, East Lansing, Michigan, North Nursery.

Cooperation: Michigan Agricultural Experiment Station-Farm Crops Dept.

Date of Planting : May 25,1960. Pre-emergence spray,TCA & Endothal,May 27.

Date of Harvest: October 19, 1960. Machine harvested.

Experimental Design : 5 x 6 Rect. Lattice, 6 reps. Analyzed as random block.

Size of Plots : 8 rows x 20 feet. 28" between rows.

Harvested area per plot for Root Yield : 6 rows x 20 feet. machine topped.

Samples for Sucrose Determination : Two samples of 10 beets each from each plot selected at random from piles.

Stand Counts : Harvested beets counted when weighed.

Recent Field History : Continuous beets(agronomic evaluation tests) since 1958. Each year 1000# 5-20-20 plowed down.

Fertilization of Beet Crop : 1000# 5-20-20 plowed down.

Black Root Exposure : Moderate. Infected sorghum seed inoculum applied with beet seed at planting.

Leaf Spot Exposure : Moderate burning over field by mid September. Powdered beet leaf inoculum applied with a John Bean Row Crop sprayer July 29.

Other Diseases and Pests: Small amount of mosaic and Savoy appeared late in season.

Soil and Seasonal Conditions : ~~Minimum tillage~~ (plow-plant) used. Field was plowed slightly wetter than desirable. Adequate rainfall during growing season. Light frost touched leaves morning of Oct.1. Blackened leaves in irregular areas throughout the field. Probably lowered the sugars.

Reliability of Test : Good. However, frost damage may have made sucrose data less reliable.

Cooperator: Michigan Agricultural Experiment Station-Farm Crops Dept. Year: 1960

Location: M. S. U. farm, East Lansing, Michigan, North Nursery. Expt: 11

5 X 6 Rectangular Lattice Design - 6 repl. - Analyzed as Randomized Block

(Results given as 6 plot averages)

Variety and Description	Acre-Yields Gross Sugar	Acre-Yields Roots	Sucrose	Purity	Beets per 100' of row
	Pounds	Tons	Percent	Percent	Number
SL 122 ms X SP 5460-0	3,464	11.94	14.41	88.98	81
SP 59B11-00 (58B2-mm sel.)	2,167	10.14	10.76	85.94	70
SP 59B13-0 (557-0 mm sel.)	2,578	9.45	13.60	88.40	70
SP 59B18-0 (02--XUS401 MM)	5,619	17.62	15.94	89.00	88
SP 59B15-0 (5832-0 mm sel.)	2,485	10.61	11.79	87.70	73
SL 119 ms X SP 5460-0	3,447	12.58	13.65	89.11	77
SP 59B17-0 (58B1-mm sel.)	3,039	11.81	12.61	86.86	71
SP 59G6-01 (PI 254575) mm	3,000	14.08	10.43	86.68	79
SP 59G6-02(SL 122 X above)	3,654	14.21	12.68	88.07	80
SP 59G7-01 (PI 254576) mm	3,439	14.86	11.63	88.03	92
SP 59G7-02(SL 122 X above)	3,366	13.85	12.09	90.19	82
SP 5481-0 LSR BRR MM	3,742	14.14	12.58	87.49	81
SP 5822-0 extraLSR BRR MM	3,994	13.25	14.91	89.98	74
SP 5932-01	3,352	12.33	13.60	89.47	81
SP 5932-02	2,584	11.32	11.28	87.30	72
SP 5933-0	2,594	11.62	11.14	87.26	76
SP 5934-01	2,841	10.77	12.94	86.84	73
SP 5935-0	2,673	9.94	13.28	87.22	67
SP 5937-0	3,692	12.68	14.35	88.17	86
SP 5938-0	2,504	9.70	12.77	86.84	67
SP 5941-01	3,678	14.25	12.78	89.30	77
SP 5942-01	3,978	13.87	14.23	89.10	77
SP 59500-01	3,557	12.60	13.99	88.91	79
SP 59693-01	3,719	14.14	13.11	88.41	77
SL 119 X(601aa X UI 113)	2,792	10.86	12.65	88.91	79
SL 122X(UI114X(60aaX113))	3,068	11.16	13.73	88.86	82
SL 122 X UI 114	3,331	12.11	13.58	88.85	83
Saginaw C361HO X SP 5481-0					
E. Lansing SP 60B1-0 mm	3,551	12.82	13.69	88.14	83
(NB 1 X NB 4) X SP 5512-0	3,658	14.25	12.64	88.06	78
SP 5931-0	3,011	12.02	12.32	87.28	76
General Mean	3,286	12.50	12.97	88.18	78
S.E. Var. Mean	311.9	.6557	.7985	.7242	2.9
S.E. Var. Mean as % Gen.Mean	9.49	5.25	6.16	0.82	3.72
Diff. for Sig. (odds 19:1)	872	1.83	2.23	2.03	8.00

Random Block Analysis — Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between replications	5	4,423,339	24.4309	27.4715	21.2176	619
Between varieties	29	2,629,968	20.0334	9.2643	6.5507	204
Remainder - Error	145	583,746	2.5804	3.8266	3.1472	49
Total	179					
Calculated F. value	29/145	4.51**	7.76**	2.42**	2.08**	4.16**

AGRONOMIC EVALUATION TEST - 1960

Conducted by: M. R. Berrett.

Location: Detroit Stake Farm, Merrill, Michigan.

Cooperation: F. & M. Beet Sugar Association, Michigan Sugar Co.

Date of Planting: May 24, 1960.

Date of Harvest: October 21, 1960.

Experimental Design: 5 x 6 Triple Lattice, Design #12.

Size of Plots: 8 rows x 20 feet, 32 inches between rows.

Harvested Area per Plot for Root Yield: 4 rows x 18 feet.

Samples for Sucrose Determination: Ten consecutive beets from each of outside harvested rows.

Stand Counts: Harvested beets counted when weighed.

Recent Field History: 1957 - Sugar Beets, 500# 5-20-10 & Boron; 1958 - Corn 400# 6-24-12 & 10 tons manure; 1959 - Corn 400# 6-24-12.

Fertilization of Beet Crop: 400# 10-20-10 & Boron & 50# N sidedressed.

Black Root Exposure: None.

Leaf Spot Exposure: None.

Other Diseases and Pests: None.

Soil and Seasonal Conditions: Moist seedbed. Generally good growing conditions throughout season.

Reliability of Test: Good.

Cooperator: F. & M. Beet Sugar Association. Year: 1960

Location: Detroit Stake Farm, Merrill, Michigan Expt: 12

5 X 6 Rectangular Lattice Design - 6 repl. - Analyzed as Randomized Block

(Results given as 6 plot averages)

Variety and Description	Acre-Yields: Gross Sugar	Acre-Yields: Roots	Sucrose	Purity	Beets per 100' of row
	Pounds	Tons	Percent	Percent	Number
SL 122 ms X SP 5460-0	6,173	18.13	17.02 5	88.24	96
SP 59B11-00 (58B2-mm sel.)	4,955	15.32	16.20	87.98	75
SP 59B13-0 (557-0 mm sel.)	4,946	15.26	16.19	87.92	80
SP 59B18-0 (02--XUS401 MM)	6,975 2	20.52 2	17.01 6	88.04 11	101
SP 59B15-0 (5832-0 mm sel.)	5,049	16.70	15.13	86.60	64
SL 119 ms X SP 5460-0	6,046	17.43	17.32 3	88.43	101
SP 59B17-0 (58B1-mm sel.)	5,259	16.32	16.11	86.05	75
SP 59G6-01 (PI 254575) mm	5,958	18.86	15.82	85.66	75
SP 59G6-02(SL 122 X above)	7,097 1	21.98 1	16.14	86.60	82
SP 59G7-01 (PI 254576) mm	6,596	20.50	16.10	86.98	91
SP 59G7-02(SL 122 X above)	6,634	20.12	16.53	88.72 2	84
SP 5481-0 LSR BRR MM	6,228	19.19	16.24	86.70	83
SP 5822-0 extraLSR BRR MM	5,817	17.42	16.72	88.69	92
SP 5932-01	5,634	17.60	16.00	87.83	92
SP 5932-02	5,473	17.29	15.83	87.55	90
SP 5933-0	5,503	17.71	15.54	87.57	87
SP 5934-01	5,248	16.13	16.33	88.60	82
SP 5935-0	4,713	14.75	16.03	87.60	82
SP 5937-0	5,636 16	17.00 18	16.62 9	87.72 15	88
SP 5938-0	4,712	14.61	16.14	87.47	75
SP 5941-01	5,773	19.02	15.22	86.97	72
SP 5942-01	6,142	18.79	16.36	87.49	91
SP 59500-01	5,789	17.12	16.89	88.74 1	91
SP 59693-01	5,584	17.29	16.22	87.32	86
SL 119 X(601aa X UI 113)	5,491	16.03	17.15 4	88.47	98
SL 112X(UI114X(601aaX113))	5,619	16.11	17.48 1	88.56	101
SL 122 X UI 114	5,843	16.78	17.41 2	88.38	95
Saginaw C361H0 X SP 5481-0	5,970	18.34	16.34	86.92	82
E. Lansing SP 60B1-0 mm					
(NB 1 X NB 4) X SP 5512-0	6,476	19.68	16.52	87.25	94
SP 5931-0	5,569	17.00	16.38	88.04	85
General Mean	5,763	17.63	16.36	87.64	86
S.E. Var. Mean	212.8	.6400	.2338	.6998	3.6
S.E. Var. Mean as % Gen.Mean	3.69	3.63	1.43	0.80	4.19
Diff. for Sig. (odds 19:1)	595	1.79	0.65	NS	10

Random Block Analysis — Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between replications	5	1,815,648	27.3224	6.5808	42.3030	135
Between varieties	29	2,237,784	19.4702	2.0977	3.9626	527
Remainder - Error	145	271,848	2.4580	.3280	2.9389	77
Total	179					
Calculated F. value	29/145	8.23**	7.92**	6.40**	NS	6.84**

Cooperator: Combined analysis Year: 1960

Location: E. Lansing, & Merrill, Michigan Expt.: 11 & 12

5 x 6 Rectangular Lattice Design - 6 repl. - Analyzed as Randomized Block

(Results given as 6 plot averages)

Variety and Description	Acre-Yields: Gross Sugar	Acre-Yields: Roots	Sucrose	Purity	Beets Per 100' of row
	Pounds	Tons	Percent	Percent	Number
SL 122 ms X SP 5460-0	4,818	15.03	15.70	88.61	88
SP 59B11-00 (58B2-MM sel.)	3,561	12.72	13.48	86.95	73
SP 59B13-0 (557-0 mm sel.)	3,762	12.36	14.90	88.16	75
SP 59B18-0(02--XUS401 MM)	6,296 1	19.07 1	16.47 1	88.51	94
SP 59B15-0(5832-0 mm sel.)	3,766	13.65	13.46	87.15	68
SL 119 ms X SP 5460-0	4,747	15.00	15.48	88.77	89
SP 59B17-0(58B1- mm sel.)	4,148	14.07	14.35	86.45	73
SP 59G6-01(PI 254575) mm	4,479	16.47	13.12	86.16	76
SP 59G6-02(SL 122 X above)	5,375 2	18.09	14.41	87.33	80
SP 59G7-01 (PI 254576) mm	5,017 5	17.67	13.86	87.50	91
SP 59G7-02 (SL 122 X above)	5,000 6	16.98	14.31	89.46	83
SP 5481-0 LSR BRR MM	4,985	16.66	14.41	87.09	82
SP 5822-0 extra LSR BRR MM	4,905	15.34	15.81	89.33	82
SP 5932-01	4,492	14.96	14.80	88.65	87
SP 5932-02	4,029	14.30	13.55	87.42	81
SP 5933-0	4,048	14.66	13.34	87.41	82
SP 5934-01	4,044	13.45	14.63	87.72	77
SP 5935-0	3,693	12.34	14.65	87.41	74
SP 5937-0	4,663 14	14.84	15.48	87.95	87
SP 5938-0	3,607	12.15	14.45	87.15	71
SP 5941-01	4,726	16.63	14.00	88.14	74
SP 5942-01	5,060 4	16.33 9	15.29 8	88.29 11	84
SP 59500-01	4,672	14.86	15.44	88.82	84
SP 59693-01	4,652	15.72	14.66	87.86	82
SL 119 X(601aa X UI 113)	4,141	13.45	14.90	88.69	88
SL 122X(UI114X(601aaX113))	4,343	13.63	15.60	88.70	91
SL 122 X Ul 114	4,587	14.44	15.49	88.62	89
Saginaw C361HO X SP 5481-0	4,760*	15.58*	15.02*	87.53*	82*
E. LANSING SP 60B1-0 mm					
(NB 1 X NB 4) X SP 5512-0	5,067 3	16.96	14.58	87.65	85
SP 5931-0	4,289	14.51	14.35	87.66	80
General Mean	4,524	15.06	14.66	87.90	82
S.E. Var. Mean	227.4	.4647	.5129	.4847	4.1
S.E. Var. Mean as% Gen.Mean	5.03	3.09	3.50	0.55	4.98
Diff. for Sig. (odds 19:1)	658	1.34	1.48	1.40	12
(odds 99:1)	886	1.81	2.00	1.89	16

* average of two different varieties hence not valid for comparison.

Variety X Location Analysis Variance Table

Source of Variation	D/F	Mean Squares: Gross Sugar	Roots	Sucrose	Purity	Beets per 100' of row
Between Locations	1	92,087,436	395.5234	172.6528	4.4228	1,127
Betweem Varieties	29	707,880	6.1471	1.3551	1.2980	88
Var. X Loc.	29	103,407	0.4319	0.5260	0.4697	33
Total	59					
Calculated F. value	29/29	6.85**	14.23**	2.58**	2.76**	2.68**

Leaf Spot Readings, Plant Industry Station, on Varieties Included in Nursery Tests given on pages 286-290.

Variety	Leaf Spot[1]	Variety	Leaf Spot[1]
SP 5822-0	3.0	SP 59G6-01	5.3
SP 5931-0	4.3	SP 59G6-02	5.3
SP 5932-01	4.5	SP 59G7-01	5.3
SP 5932-02	4.0	SP 59G7-02	5.3
SP 5933-0	4.5	SP 59B11-0	6.0
SP 5934-01	4.5	SP 59B13-0	5.0
SP 5935-0	4.0	SP 59B17-0	4.3
SP 5937-0	5.0	SL 119MS X SP 5460-0	5.0
SP 5938-0	4.0	SL 122MS X SP 5460-0	5.0
SP 5941-01	4.5	SP 5481-0	4.3
SP 5942-01	4.5	US 401	4.9

[1] Leaf spot readings August 25, 1960, by G. E. Coe.

Scale of readings: 1 = no blight; 10 = destruction of foliage, except for whorls of small leaves in center of crown.

AGRONOMIC EVALUATION TEST, 1960

Conducted by: Richard Zielke, H. L. Bush and D. L. Sunderland

Location: Glen Haas Farm, Fremont, Ohio

Cooperation: Northern Ohio Sugar Company

Date of Planting: April 23, 1960

Date of Harvest: September 22-23, 1960

Experimental Design: Triple Lattice

Size of Plots: 6 rows x 22 feet planted (30 inch rows)

Harvest Area per Plot for Root Yield: 6 rows x 18 feet

Samples for Sucrose Determinations: 2 samples per plot, each 1 row x 18 feet

Stand Counts and Bolter Counts: See footnote (e) for July 22 counts
Beets counted in laboratory for harvest stand
No bolters developed

Recent Field History: Alfalfa Sod

Fertilization of Beet Crop: 560 lbs. per acre of 12-12-12 disked in

Leaf Spot Exposure: Mild, rather late development

Black Root Exposure: Severe

Curly Top Exposure: None noted

Other Diseases: Rhizoctonia caused some loss in stand

Soil and Seasonal Conditions: Abnormal conditions prevailed at the test site. Six weeks of rain followed dry conditions at planting time. Rainfall from mid-August to harvest date was negligible. High humidity was conducive to leaf spot development during September.

Cooperator: Northern Ohio Sugar Company by Richard Zielke, H. L. Bush and D. L. Sunderland

Location: Glen Haas Farm, Fremont, Ohio Year: 1960

(Results given as 6 plot averages)

Variety	Acre Yield: Sugar: Recoverable[a] (lbs.)	Acre Yield: Sugar: Gross (lbs.)	Acre Yield: Roots (tons)	Sucrose (%)	Thin Juice App. Purity (%)	Leaf Spot[d]	Beets: July 22[e] 40' row (No.)	Beets: Harvest 100' row (No.)
SP5481-0	4395	5398	17.30	15.60	90.81	1.2	47	112
US401	4216	5194	17.20	15.10	90.71	2.0	42	104
SP5822-0	4143	5044	16.45	15.33	91.18	1.0	43	107
SP5510-0	4125	5219	16.77	15.56	89.62	1.8	39	102
SP5714-0	3802	4756	15.78	15.07	90.09	1.0	43	101
119MS x 5481-0 (mm)	3718	4737	15.40	15.38	89.36	2.7	43	101
122MS x 5481-0 (mm)	3659	4538	14.88	15.25	90.44	3.0	46	102
122MS x 5460-0 (mm)	3621	4575	15.07	15.18	89.70	2.8	39	100
SP5931-0 (mm)	3534	4566	15.15	15.07	88.85	1.7	37	94
119MS x 5510-0 (mm)	3501	4345	14.68	14.80	90.41	2.3	39	97
122MS x 5713-0 (mm)	3439	4341	14.43	15.04	89.74	3.3	43	97
119MS x 5460-0 (mm)	3419	4281	13.98	15.31	90.03	2.7	42	92
122MS x 5510-0 (mm)	3311	4236	13.99	15.14	89.22	4.0	42	98
119MS x 5713-0 (mm)	3281	4116	13.38	15.38	89.96	3.3	45	89
General Mean[f]	3692	4638	15.26	15.18	89.90	2.0	40	99
S.E. Variety Mean(Sm)	-	196.73	.6002	.2405	.4258	-	-	-
Sm/Gen. M (%)	-	4.24	3.94	1.58	0.47	-	-	-
LSD 5% pt.	407[b]	511	1.68	0.69	1.23	-	-	-

Variance Table

Source of Variation	DF	Mean Squares: Gross Sugar[c] (lbs.)	Mean Squares: Roots (tons)	Mean Squares: Sucrose (%)	Mean Squares: Purity (%)
Replicates	5	-	27.35	2.3660	7.6560
Component (a)	12	-	1.21	.5742	1.5625
Component (b)	12	-	2.07	.3450	1.0833
Blocks (eliminating varieties)	24	-	1.66	.4596	1.3229
Varieties (ignoring blocks)	24	-	11.09	.4158	2.9033
Error (Intra-Block)	96	-	2.28	.3470[g]	1.0878[g]
Error (Random Block)	120	-	2.16[g]	.3695	1.1348
Total	149	-	4.45	.4440	1.6385
Calculated F Value	-	-	5.13**	NS	2.67**

(a,(b,(c See page 299.

(d 0 = no evidence of disease, 10 = complete necrosis due to leaf spot

(e Stand count in center 2 rows of each plot on July 22. The count could be used as an index of resistance to early root diseases.

(f General mean for 25 varieties included in complete test

(g Error term used

AGRONOMIC EVALUATION TEST, 1960

Conducted by: Richard Zielke, H. L. Bush and D. L. Sunderland

Location: K. Krauss Farm, Findlay, Ohio

Cooperation: Northern Ohio Sugar Company

Date of Planting: April 20, 1960

Date of Harvest: November 1-2, 1960

Experimental Design; Triple Lattice

Size of Plots: 6 rows x 22 feet planted (30 inch rows)

Harvest Area per Plot for Root Yield: 6 rows x 18 feet

Samples for Sucrose Determination: 2 samples per plot, each 1 row x 18 feet

Stand Counts and Bolter Counts: Beets counted in laboratory for stand
No bolters developed

Recent Field History: Red Clover Sod

Fertilization of Beet Crop: 570 lbs. per acre of 10-20-10 plowed under
185 lbs. per acre of 6-24-12 with seed

Leaf Spot Exposure: Mild, late development

Black Root Exposure: Mild

Curly Top Exposure: None noted

Other Diseases: Slight Rhizoctonia

Soil and Seasonal Conditions: Good growing conditions prevailed through the summer. Rainfall during September and October was negligible. High humidity conditions early in September favored the development of leaf spot in the test.

Cooperator: Northern Ohio Sugar Company by Richard Zielke, H. L. Bush and D. L. Sunderland

Location: K. Krauss Farm, Findlay, Ohio Year: 1960

(Results given as 6 plot averages)

Variety	Acre Yield: Sugar: Recoverable[a] (lbs.)	Acre Yield: Sugar: Gross (lbs.)	Acre Yield: Roots (tons)	Sucrose (%)	Thin Juice App. Purity (%)	Leaf Spot[d]	Beets per 100 ft.[e] (No.)
SP5481-0	6042	7552 1	20.69 1	18.25 1	89.95 2	1.2	110
SP5822-0	5597	6836 3	18.76 3	18.22 2	90.90 1	1.0	103
SP5510-0	5400	6940 2	19.66 2	17.65 6	88.93 10	1.0	98
122MS x 5481-0 (mm)	5069	6469 4	18.10 5	17.87 3	89.17 7	2.7	98
US401	5061	6407 5	18.70 4	17.13 13	89.53 4	2.5	96
122MS x 5460-0 (mm)	4817	6192 6	17.54 6	17.65 6	88.92 11	3.2	98
SP5714-0	4807	6024 7	17.43 7	17.28 11	89.90 3	1.0	95
119MS x 5481-0 (mm)	4700	6017 8	17.36 8	17.33 9	89.08 8	2.8	101
119MS x 5460-0 (mm)	4659	5927 9	17.13 9	17.30 10	89.32 5	2.7	95
119MS x 5713-0 (mm)	4653	5918 10	16.70 12	17.72 5	89.30 6	3.2	90
122MS x 5510-0 (mm)	4479	5800 11	17.01 10	17.05 14	88.67 13	3.8	99
119MS x 5510-0 (mm)	4449	5776 12	16.81 11	17.18 12	88.58 14	3.0	96
SP5931-0 (mm)	4429	5682 13	16.17 13	17.57 8	88.97 9	2.8	92
122MS x 5713-0 (mm)	4361	5603 14	15.72 14	17.82 4	88.92 11	3.5	95
General Mean[f]	4861	6181	17.60	17.56	89.34	2.0	99
S.E. Variety Mean(Sm)	-	226.72	.5802	.2831	.4198	-	-
Sm/Gen. M (%)	-	3.67	3.29	1.61	0.47	-	-
LSD 5% pt.	499[b]	635	1.62	0.79	1.18	-	-

Variance Table

Source of Variation	DF	Mean Squares: Gross Sugar[c] (lbs.)	Mean Squares: Roots (tons)	Mean Squares: Sucrose (%)	Mean Squares: Purity (%)
Replicates	5	-	8.40	1.1340	5.8540
Component (a)	12	-	1.29	.4792	.4692
Component (b)	12	-	2.36	.4283	.7742
Blocks (eliminating varieties)	24	-	1.82	.4538	.6217
Varieties (ignoring blocks)	24	-	11.24	.7308	2.2871
Error (Intra-Block)	96	-	2.07	.4875	1.1659
Error (Random Block)	120	-	2.02[g]	.4808[g]	1.0571[g]
Total	149	-	3.72	.5430	1.4162
Calculated F Value	-	-	5.56**	1.52*	2.16**

(a, (b, (c See page 299.
(d 0 = no evidence of disease, 10 = complete necrosis due to leaf spot
(e Harvest stand
(f General mean for 25 varieties included in complete test
(g Error term used

AGRONOMIC EVALUATION TEST, 1960

Conducted by: Richard Zielke, H. L. Bush and D. L. Sunderland

Location: Ernest Gilmor Farm, Old Fort, Ohio

Cooperation: Northern Ohio Sugar Company

Date of Planting: April 16, 1960

Date of Harvest: November 8-10, 1960

Experimental Design: Triple Lattice

Size of Plots: 6 rows x 22 feet planted (28 inch rows)

Harvest Area per Plot for Root Yield: 6 rows x 18 feet

Samples for Sucrose Determination: 2 samples per plot, each 1 row x 18 feet

Stand Counts and Bolter Counts: Beets counted in laboratory for stand
No bolters developed

Recent Field History: Sugar Beets

Fertilization of Beet Crop: None plowed down.
250 lbs. per acre of 3-18-9 with seed.

Leaf Spot Exposure: Very severe. Initial infection about July 15

Black Root Exposure: Mild

Curly Top Exposure: None noted

Other Diseases: Some Rhizoctonia, especially in plots severely weakened by leaf spot.

Soil and Seasonal Conditions: Good growing conditions prevailed through the summer. High humidity conditions on this sandy loam field, coupled with beets after beets, favored the early development of leaf spot in the test. No more readings on leaf spot could be taken after September 1 because continued burning of the leaves prevented an accurate reading within most plots.

Cooperator: Northern Ohio Sugar Company by Richard Zielke, H. L. Bush and D. L. Sunderland

Location: Ernest Gilmor Farm, Old Fort, Ohio Year: 1960

(Results given as 6 plot averages)

Variety	Acre Yield: Sugar: Recoverable[a] (lbs.)	Acre Yield: Sugar: Gross (lbs.)	Acre Yield: Roots (tons)	Sucrose (%)	Thin Juice App. Purity (%)	Leaf Spot[d] (Aug.8)	Leaf Spot[d] (Aug.18)	Beets[e] per 100 ft. (No.)
SP5822-0	4727	5629	18.31	15.37	92.12	1.0	1.7	117
SP5481-0	4021	4686	16.63	14.09	93.17	2.0	2.8	130
SP5510-0	3538	4166	15.89	13.11	92.76	2.2	3.0	123
122MS x 5460-0 (mm)	3418	3916	14.44	13.56	93.99	3.8	5.0	130
US401	3378	3953	15.55	12.71	93.07	3.0	3.7	125
SP5714-0	3296	3854	14.62	13.18	93.08	1.7	2.3	116
SP5931-0 (mm)	3198	3754	13.63	13.77	92.84	3.0	3.8	117
119MS x 5713-0 (mm)	3040	3650	13.89	13.14	91.91	3.0	4.3	123
119MS x 5481-0 (mm)	2922	3490	13.25	13.17	92.13	3.5	4.0	113
122MS x 5713-0 (mm)	2870	3343	13.05	12.81	93.26	4.0	5.2	118
119MS x 5460-0 (mm)	2803	3281	12.54	13.08	93.03	3.5	4.3	111
122MS x 5481-0 (mm)	2652	3060	12.50	12.24	93.75	3.5	4.5	118
119MS x 5510-0 (mm)	2620	3040	12.20	12.46	93.47	3.7	4.8	107
122MS x 5510-0 (mm)	2604	3006	11.67	12.88	93.67	4.3	5.3	117
General Mean[f]	3403	3989	14.64	13.58	92.97	2.7	3.7	120
S.E. Variety Mean (Sm)	-	211.38	.5559	.5017	.4594	-	-	-
Sm/Gen. M (%)	-	5.30	3.80	3.70	0.49	-	-	-
LSD 5% pt.	534[b]	625	1.61	1.51	1.30	-	-	-

Variance Table

Source of Variation	DF	Mean Squares: Gross Sugar[c] (lbs.)	Mean Squares: Roots (tons)	Mean Squares: Sucrose (%)	Mean Squares: Purity (%)
Replicates	5	-	21.74	14.8840	1.6940
Component (a)	12	-	3.42	6.5033	1.3308
Component (b)	12	-	1.95	3.1283	1.4017
Blocks (eliminating varieties)	24	-	2.69	4.8258	1.3663
Varieties (ignoring blocks)	24	-	17.29	4.7708	1.9879
Error (Intra-Block)	96	-	1.85[g]	1.5131	1.2666
Error (Random Block)	120	-	2.02	2.1737	1.2865
Total	149	-	5.14	3.0185	1.4132
Calculated F Value	-	-	9.35**	3.15**	1.57*

(a,(b,(c See page 299.
(d O = no evidence of disease, 10 = complete necrosis due to leaf spot
(e Harvest stand
(f General mean for 25 varieties included in complete test
(g Error term used

Cooperator: Great Western Sugar Company by H. L. Bush and R. R. Wood

Location: Great Western Sugar Co., Experiment Station Farm, Longmont, Colo.

Year: 1960

(Results given as 6 plot averages)

Variety	Acre Yield: Recoverable Sugar[a] (lbs.)	Acre Yield: Gross Sugar (lbs.)	Acre Yield: Roots (tons)	Sucrose (%)	Thin Juice App. Purity (%)	Bolters (%)	Beets per 100 ft. (No.)
GW674	6551	7124	21.24	16.77	96.37	0.20	94
US104	5462	5858	18.17	16.12	97.17	0.30	93
General Mean[d]	6862	7504	23.19	16.18	96.15	0.08	96
Sm	-	202.93[c]	.5649	.1898	.3047	-	-
Sm/Gen. M (%)	-	2.70	2.44	1.17	0.32	-	-
LSD 5% pt.	567[b]	620	1.74	0.56	0.86	-	-

(a,(b,(c See page 299.

(d Mean for 16 varieties in complete test

Footnotes for pages 293, 295, 297, and 298.

(a <u>Recoverable Sugar</u>

A technique, whereby thin juice purity could be determined from small samples was first used in 1953, following methods recently developed in the G. W. Research Laboratory at Denver. Using the resultant purity figure, a calculated "Recoverable Sugar" is obtained. An example of the calculation is as follows:

Sugar in beets = 12.00%
Standard total losses = 0.30%
Sugar on beets at sugar end = 12.00 - 0.30 = 11.70%

Assume standard molasses purity = 62.5%
100.0 - 62.5 = 37.5% Impurities on solids in molasses

$\frac{62.5}{37.5}$ = 1.6667% Sugar on impurities in molasses

Sugar sacked

85% purity thin juice = 15% impurities

$\frac{15}{85}$ = 17.6471% impurities on sugar

Sugar end = 11.70 x 17.6471% = 2.06471% on beets
Molasses produced = 2.06471 x 1.66667 = 3.4413% on beets
Sugar sacked = 12.00 - (0.30 + 3.4413) = 8.2587%

Recoverable sugar = $\frac{8.2587}{12.00}$ = 68.82%

(b <u>Approximation</u> - Calculated as percentage of "difference required for significance for "gross" sugar on basis of relationship between general means for "Gross" and "Recoverable" sugar.

(c <u>Calculated from the formula:</u>

$$\text{S lbs. sugar} = \sqrt{\left(\frac{\text{S lbs. beets}}{\text{Mean lbs. beets}}\right)^2 + \left(\frac{\text{S \% sugar}}{\text{Mean \% sugar}}\right)^2}$$

PART XI

DEVELOPMENT OF BASIC BREEDING MATERIAL

- -

SCREENING TESTS FOR BLACK ROOT RESISTANCE

Foundation Project 26

G. E. Coe C. L. Schneider

GREENHOUSE SCREENING TESTS FOR BLACK ROOT RESISTANCE

C. L. Schneider

Materials and Methods

Tests were made in the greenhouse to determine the degree of black root resistance of strains of *Beta vulgaris* and *B. maritima*. Following are the types of material tested:

A. *Sugar beet strains*. These were developed in the U.S.D.A. program of breeding to establish varieties suitable for the Great Lakes region and were furnished by G. E. Coe. The strains were derived from material previously selected under natural exposures to black root and Cercospora leaf spot. Included were 654 multigerm strains and 215 monogerm hybrids which were produced through the use of multigerm pollinators.

B. *Beta vulgaris introductions*. These are accessions from the Regional Plant Introduction Station, Ames, Iowa, and were furnished by W. H. Skrdla. They consisted chiefly of culinary types introduced from Europe and Asia. These tests supplement those with similar material from the same source reported in the Sugar Beet Research 1959 Report.

C. *Beta maritima introductions*. These consisted of increases of collections furnished by cooperators from Europe.

Seedlings of each entry were grown in four replicated 6-inch clay saucers of steamed soil. After emergence, plants were thinned to a maximum of 25 per saucer. An aqueous suspension of zoospores of a

monosporous isolate of Aphanomyces cochlioides was then applied to the soil of each saucer. The dosage of zoospores varied between blocks and tests and ranged from 300,000 to 1,000,000 zoospores per saucer. Since black root severity increases with temperature, the highest dosages of inoculum were employed during the months when greenhouse temperatures were lowest. About one month after inoculation the degree of susceptibility to disease was determined according to the number of plants surviving and the severity of black root symptoms. Variety US 401, moderately resistant to black root, was included in each test as a basis for evaluating the relative black root resistance of each entry. The number of entries in each test was either 22 or 34.

Results

All entries became infected upon exposure to the pathogen and none appeared to be immune. However, the entries differed markedly in degree of tolerance to infection (Table 1).

A preponderant number of the sugar beet breeding strains were equal to or exceeded the degree of resistance of check variety US 401. Some were vastly superior (Fig. 1). During the past three years, a gradual increase in the black root resistance of multigerm and monogerm breeding strains as well as new hybrids included in the tests has been noted. This has necessitated the use of increased dosages of inoculum to ensure a degree of infection that would differentiate the different levels of resistance in the new breeding material.

Wide differences in resistance were noted among the Beta vulgaris and B. maritima introductions (Tables 1 and 2; Fig. 2). The majority were considerably more susceptible than US 401.

Table 1. Distribution of entries in greenhouse Aphanomyces screening tests according to disease rating.

Types of Material	No. Entries Tested	Ave. Disease Rating	Number of entries in each disease rating class 1/											
			60	70	80	90	100	110	120	130	140	150	160	170
Sugar beet breeding strains, multigerm.	654	95.6		1	50	272	256	64	10	1				
Monogerm hybrid	215	92.0		9	45	79	61	12	5	1	2			
Beta vulgaris introductions, mainly culinary types.	71	129.0				1	13	10	7	12	6	11	9	2
Beta maritima introductions.	20	117.0					2	8	5	4	1			

1/ Disease rating = percent disease as compared with commercial sugar beet variety US 401 which is 100. The higher the rating, the greater the amount of disease.

Table 2.
Disease Ratings of *Beta vulgaris* strains from Ames, Iowa, Plant Introduction Station, Inoculated with *Aphanomyces cochlioides* in the Greenhouse

P.I. No.	Origin	Disease Rating[1]	P.I. No.	Origin	Disease Rating[1]
117115	Turkey	113	173642	Turkey	140[2]
117116	"	139	176421	"	160
117117	"	130	176423	"	127
120282	"	132	176427	"	---
120689	"	136	177269	"	133
120691	"	136	177274	Syria	105
120695	"	159	178836	Turkey	134
120696	"	147	181859	Syria	124
120703	"	156	181930	Syria	150
120704	"	126[2]	182143	Turkey	164
121296	India	101[2,3]	182145	"	161
121297	"	106[2,3]	183663	"	128
121838	"	100[2,3]	204677	"	141
124404	"	106[2,3]	204678	"	115
140353	Iran	150	205987	Sweden	113
140354	"	149	212884	India	112[2,3]
140355	"	122	218063	Pakistan	114[3]
140356	"	138	222769	Iran	122
140357	"	130	226628	"	127
140359	"	147	277010	"	128[3]
140360	"	117[2]	228340	"	126
140361	"	151	229589	"	107
140362	"	147			
141919	Manchuria	155			
142808	Iran	158			
142810	"	150	120692	Turkey	95[2,3]
142811	"	161	163181	India	95[2,3]
142812	"	172	164553	"	103[2,3]
142816	"	152	164810	"	99[2]
142817	"	166	165502	"	91[2,3]
142818	"	162	169020	Turkey	102[2]
163177	India	106	169031	"	105[2]
164671	India	133	172733	"	101[2]
171508	Turkey	133	172734	"	99[2]
171515	"	105[2]	173841	India	100[2,3]
171517	"	123	173843	India	102[2,3]
171520	"	155	174062	Turkey	102[2]
172739	"	162			

1/ Disease Rating = percent disease as compared with commercial sugar beet variety US 401 which = 100. The higher the rating, the greater the amount of disease. Ratings are presented as means of 4 replicates.

2/ Results expressed as averages of ratings obtained in 2 different experiments, each with 4 replicates.

3/ A tendency toward annualism was noted, in that plants produced seedstalks within 40 days after planting and at relatively warm temperatures.

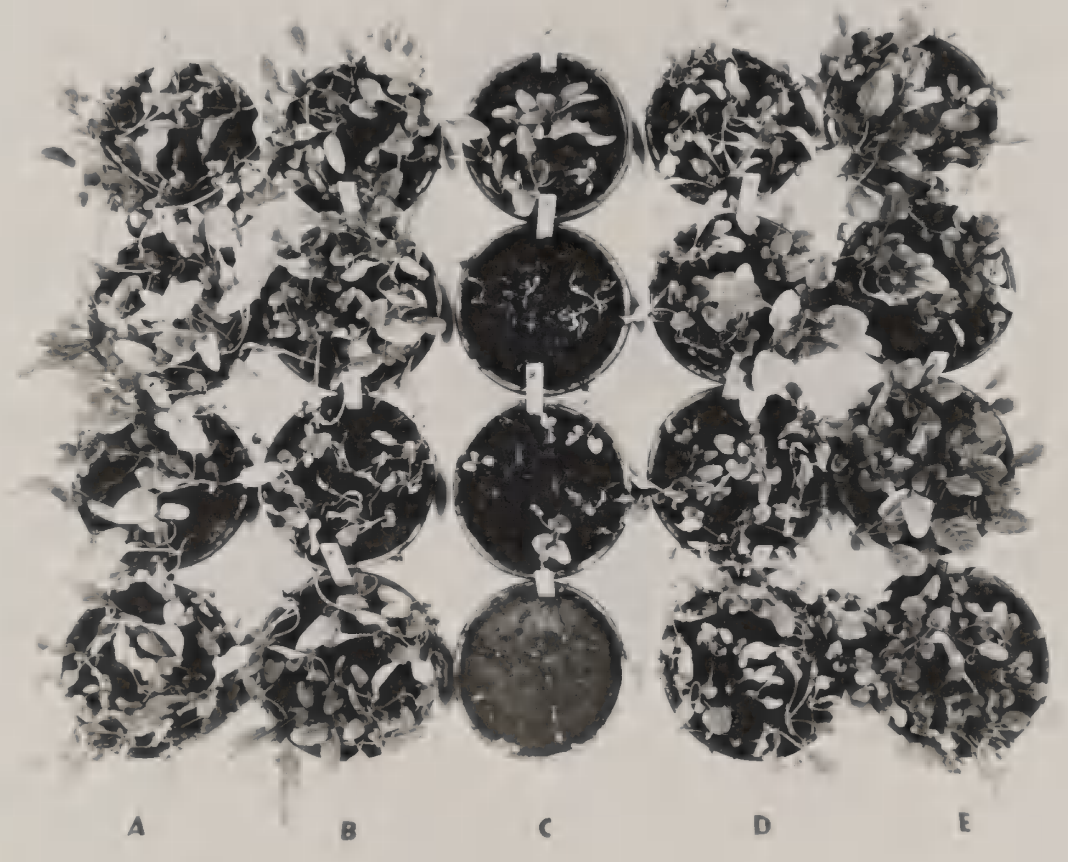

Fig. 1. Four monogerm hybrids in soil infested with Aphanomyces cochlioides showing high degree of resistance to black root compared with check variety US 401 in center. A = SP 59485-1; B = SP 59495-1; C = US 401; D = SP 59489-1; E = SP 59462-1.

Fig. 2. Difference in black root resistance between 2 strains of Beta maritima in soil infested with Aphanomyces cochlioides. A = Sugar beet variety US 401, B = B. maritima (SP 54765-0), C = B. maritima (SP 54756-0).

DEVELOPMENT OF BASIC BREEDING MATERIAL

G. E. Coe

Most of the research at Beltsville under Foundation Project 26 has been directed toward varietal improvement in resistance to Cercospora leaf spot and black root. Breeding material produced by this research program has contributed to the varieties and new developments that are evaluated in tests reported in Part X. This part of the report presents new strains that are being developed, results obtained in interspecific hybridizations, polyploidy, and a method of leaf spot inoculation.

Progress of Species Hybrids

In the Spring of 1960, plants of an amphidiploid line of a hybrid between Beta patellaris X B. procumbens were interspaced in a seed plot with tetraploid sugar beets. Although seed was produced on almost every plant in the isolation, no interspecific hybrids between the amphidiploids and the sugar beets were found in the progenies.

Hybrids between B. corolliflora ($2n = 36$) X tetraploid sugar beets were first produced in 1953. Seed increases of this hybrid could not be obtained, but backcross plants were obtained using B. corolliflora as the recurrent pollen parent. Two subsequent generations have been produced from this line of breeding. At the time of these subsequent seed increases, tetraploid plants of sugar beet were placed with the hybrid plants in the attempt to obtain further crossing to the sugar beet. It has been difficult to determine with complete certainty the extent to which crossing with either parental line has been successful in these last two generations. The progenies derived from the sugar beet parents tend to resemble sugar beets, and the progenies derived from the backcross plants tend to resemble B. corolliflora. It can be said with certainty that the latter progenies have varying mixtures of B. corolliflora and B. vulgaris chromosomes, as evidenced by the great morphological variations among and within the progenies. In some progenies, a few monogerm plants have been found. The source of the monogerm characteristic is in doubt, since only multigerm sugar beets have been used in the crosses. Pollen contamination does not seem to be the explanation. The study of the inheritance of this and other unusual characteristics in this hybrid material should be quite interesting.

Polyploidy

A test of "comparable" diploid and triploid hybrids was conducted in the Beltsville nursery in 1960. The diploid hybrid, SP 5940-02, was produced by crossing SL 91 MS 2^n X SP 5481-0 2^n; and the triploid hybrid, SP 5940-01, was produced by crossing SL 91 MS 4^n X SP 5481-0 2^n. Eight replications of each were planted, each replication consisting of 4 rows 20 ft. long. The middle two rows of each replication were taken for sugar analyses and refractometer readings. The results of these tests are summarized in Table 1.

Table 1. Average of 8 replications for foliage vigor, leaf spot resistance, number of roots harvested, yield, percent sucrose, and percent purity in comparable diploid and triploid hybrid beets.

Hybrid Variety	Foliage Vigor 7/20	Leaf Spot Reading 1/ 8/3	Leaf Spot Reading 1/ 8/12	Roots Harvested No./Acre	Roots Harvested Tons/Acre	Percent Sucrose	Percent Purity
Triploid SP 5940-01	3.9	4.6	5.0	19,874	23.92	10.00	76.79
Diploid SP 5940-02	4.1	4.4	5.0	22.903	25.87	10.06	78.04

1/ Leaf spot readings are average of 4 rows based on a scale of 0 to 10: 0 = immunity; 10 = death of all plants, caused by leaf spot.

It was noted that the triploid hybrid became more severely infected with leaf spot more rapidly than did the diploid hybrid; but later, the diploid hybrid became just as severely infected as the triploid hybrid. The triploid hybrid might be expected to have less leaf spot resistance than the diploid hybrid, since it had 2 sets of chromosomes from the susceptible parent and one set of chromosomes from the resistant parent, SP 5481-0. The diploid hybrid had, of course, one set of chromosomes from the susceptible parent and one set of chromosomes from the resistant parent. The only significant differences between the performance of the two hybrids at Beltsville were the number of roots harvested and the root yield, both of which were better in the diploid hybrid. It should not be concluded from this test, however, that the hybrids on the diploid level are equal to or superior to triploid hybrids, because of the difference between the two hybrids in resistance to leaf spot and in resistance to black root. There was a moderate epidemic of black root in this test which undoubtedly had some effect on root yield and on the number of roots surviving until harvest. In locations where one or more diseases are serious, resistance of a variety to those diseases is probably a much more important factor than the level of ploidy. New diploid and triploid hybrids were produced in 1960, using diploid and tetraploid US 401 as pollinators on 2 diploid male-sterile monogerm lines produced at Beltsville. The male-sterile lines have resistance to leaf spot that is slightly better than US 401 and resistance to black root that is about equal to US 401. These new hybrids should more accurately measure the merits of diploidy vs. triploidy in tests at Beltsville, with a minimum effect caused by differences between the two varieties in resistance to two major diseases.

Sixty progenies from selected tetraploid plants were in the nursery tests in 1960. Among these were the most productive tetraploids ever grown at Beltsville. The productivity of these selections have furnished additional incentive for further investigations of tetraploid breeding.

Tests with Irradiated Materials

F_2 progenies of crosses between plants from thermal-neutron irradiated seed and plants from nonirradiated seed were grown in the 1960 nursery test. A brief description of this material was presented in Sugar Beet Research, 1958 Report. These progenies occupied approximately 1/10 of an acre in the test. Every plant was examined in the attempt to locate beneficial mutations which might have occurred. Particular attention was given to the search for immunity or extreme resistance to Cercospora leaf spot. Unfortunately, not a single plant exhibited any characteristics that could be designated as a "beneficial mutuation." If any did occur, their beneficial effects were either obscured by detrimental mutations or were so minor that they were not detected.

Tests on Methods of Leaf Spot Inoculation

The need of a method of inoculation for the induction of a more severe epidemic of Cercospora leaf spot in a shorter period of time has recently become apparent in the breeding work at Beltsville. A more severe epidemic would make possible a more accurate evaluation of resistance of the various breeding lines, and bringing of the epidemic to a peak of intensity in a short period will reduce the job of weeding and other field practices that must be carried on during the build-up of the epidemic. Two experiments were conducted. In the first, a comparison was made between the old and a new method of applying the inoculum; in the second experiment, a comparison was made of inoculum prepared from susceptible sugar beet varieties with inoculum prepared from resistant sugar beet varieties.

The old method of inoculating consisted of mixing approximately 1.8 pounds of dried, ground, infected beet leaves with 50 gallons of water and applying the suspension to plants by hand with a large sponge. Fifty gallons of such inoculum was used on each acre of plants (approximately 20,000) to be inoculated. The new method consisted of mixing 200 grams of dried, ground, infected beet leaves per pound of powdered talc and applying the dust mixture to the plants in the early morning while the dew was still present. Because of inaccurate calibration of the hand duster used in the test, the leaf inoculum was applied at the rate of approximately 2.4 pounds per acre, which was about 1-1/3 times as much as applied by the "sponge method." Since the plants inoculated were in plots of a triple-lattice experimental design, one replication of each triple-lattice was inoculated by one method, and the other two replications were inoculated by the other method. The results of this experiment are given in Table 2 as the total of leaf spot readings of all 36 entries in each replication of each variety trial.

Table 2. Total of leaf spot readings of each replication of each experiment in testing 2 methods of inoculation.

Variety Trial Number	Date of Leaf Spot Reading	Total Leaf Spot Reading of 36 Entries in Replication					
		Sponge Method			Dust Method		
		First Rep.	Second Rep.	Third Rep.	First Rep.	Second Rep.	Third Rep.
1	Aug. 3	101				110	115
	Aug. 12	120				126	125
	Aug. 19	132				137	139
2	Aug. 3			111	117	137	
	Aug. 12			123	128	138	
	Aug. 19			140	129	146	
3	Aug. 3	114				127	117
	Aug. 12	131				134	130
	Aug. 19	137				146	141
4	Aug. 3		98	95	115		
	Aug. 12		129	120	134		
	Aug. 19		140	134	143		
5	Aug. 3			96	113	122	
	Aug. 12			114	121	127	
	Aug. 19			125	133	139	
6	Aug. 3	100	98				113
	Aug. 12	127	123				123
	Aug. 19	133	129				137
7	Aug. 3	90	95				108
	Aug. 12	122	125				129
	Aug. 19	131	141				136

The data in Table 2, with the exception of the 4 readings that are underlined, indicated that the dust method of inoculation gave a slightly more severe leaf spot epidemic. The regularity of the relative ranks of the readings of the replications indicates that the initial amount of infection is quite important in determining how severely the plants are diseased at any particular subsequent date. The more severe epidemic caused by the dust method might have been due to the increased dosage rate used and to the utilization of all of the inoculum. With the sponge method, great difficulty is encountered in keeping the inoculum in suspension. The sponge method has been used for the application of the ground-leaf material because the available equipment would not spray the suspension. Previous experiments have shown that straining the leaf suspension through a screen fine enough to permit application with a mechanical sprayer produces a less severe epidemic than the application of unstrained leaf suspension. With the dust method, the amount of inoculum can be doubled several times and used completely without great difficulty. The dust method is much more rapid and can be performed with a great saving in labor and expense.

The dust method was used exclusively in the second experiment testing the effect of the source of inoculum on the severity of the disease epidemic. The results of this experiment are given in table 3.

Table 3. The effect of the source of inoculum on severity of leaf spot epidemic

Variety Trial Number	Date of Leaf Spot Reading	Total Leaf Spot Readings of 36 Entries in Replications					
		Inoculum prepared from leaves of varieties susceptible to leaf spot			Inoculum prepared from leaves of varieties resistant to leaf spot		
		First Rep.	Second Rep.	Third Rep.	First Rep.	Second Rep.	Third Rep.
8	Aug. 12	105	90				106
	Aug. 18	122	108				125
	Aug. 25	128	126				130
9	Aug. 12	104	108				110
	Aug. 18	116	115				122
	Aug. 25	120	123				133
10	Aug. 12		138	129	144		
	Aug. 18		153	148	165		
	Aug. 25		160	161	170		
11	Aug. 12		117	119	129		
	Aug. 18		131	136	145		
	Aug. 25		145	155	<u>153</u>		

From the data in Table 3 it can be seen that the inoculum prepared from leaves of varieties that were more resistant to the disease produced epidemics slightly more severe than did the inoculum prepared from leaves of varieties quite susceptible to leaf spot. Counts were made to determine whether or not one source of inoculum contained more conidia than the other source. Samples from the resistant variety had from 300,000 to 475,000 conidia and recognizable conidial fragments per gram of dried ground leaves. Samples from susceptible varieties had from 480,000 to 595,000 conidia and recognizable conidial fragments per gram of dried leaves. It was concluded that increased number of conidia could not be a contributing factor to a more severe leaf spot epidemic caused by the inoculum prepared from resistant varieties. Although the differences in the readings in Table 2 are not great, they are an indication that inoculum prepared from leaves of the resistant varieties are more effective than the inoculum from the susceptible varieties. The test will be repeated in 1961.

New Breeding Lines

The "O"-type monogerm pollinators, SP 5515-0 and SP 5520-0 (Sugar Beet Research, 1957 Report, page 127), were located at Beltsville in 1954. Until 1960, no other completely "O"-types were located in some 1500 pollen plants indexed. In the fall of 1959, 207 progenies of plants being indexed were grown in the greenhouse. When these plants flowered in 1960, 6 progenies had white anthers only and were classified as "O"-types; 18 other progenies were male-sterile, but some plants in the progenies had lemon-colored anthers. It has been thought that this latter type of male-sterile line often can produce some pollen in a subsequent generation under favorable conditions. Therefore, the usefulness of this type of male sterility is questionable. Four of the 6 lines designated as "O"-type and their white anther counterparts have been planted in 4 separate overwintering isolations for seed increases and for an additional indexing to be sure that they are true "O"-types. These new "O"-type monogerm lines are considerably more productive and have more resistance to black root and leaf spot than did the "O"-types found at Beltsville in 1954. (See Sugar Beet Research, 1957 Report, page 127.) It is anticipated that they might be useful in the production of commercial hybrids.

In 1960, three new synthetic monogerm varieties were produced from clones of the mother roots of the best progenies in the 1959 nursery test. Two of these varieties produced seed in time to be planted in the 1960 nursery trials. One of them, SP 6061-0, performed fairly well. Seed increases of SP 6061-0 and the variety not tested in 1960, SP 6062-0, are being made. Each of these two varieties is expected to perform better than did the monogerm SP 5931-0 (see Part X of this report), but seed for field trials will not be available until 1962. The 1960 nursery trials indicate that another monogerm variety, SP 60300-0, should also exceed the performance of SP 5931-0. SP 60300-0 is being increased in Oregon (Part I of this report) and will be available for testing in the Great Lakes area in 1962.

PART XII

EVALUATION OF FUNGICIDES FOR CONTROL OF CERCOSPORA LEAF SPOT

H. L. Bissonnette

Investigations conducted in cooperation with the Department of Plant Pathology and Botany, Minnesota Agricultural Experiment Station, St. Paul, Minnesota.

Tests of Fungicides and their Minor Elements for the Control of Cercospora Leaf Spot of Sugar Beets

Howard L. Bissonnette

Five fungicides were evaluated for the control of leaf spot of sugar beets at their recommended rates. The three minor elements contained in these fungicides were applied also to evaluate their potential role in disease control and in the growth of the plant. The experiment was conducted at the University of Minnesota Experiment Station, Rosemount, Minnesota, during the 1960 growing season.

MATERIALS AND METHODS

The sugar beets were planted May 18. American 3S, a variety of sugar beets commonly grown in the area, was supplied by the American Crystal Sugar Company. The seedling stand was adequate for the area and was thinned by hand June 20.

The experiment was set up as a randomized block of 9 treatments with 7 replications of each treatment. The plots were 4 rows wide and 30 feet long with row spacing of 22 inches. Each plot was separated by a single row, and the experiment surrounded by a 6-row border. The border rows and the single rows separating the plots were inoculated July 3rd with washings from diseased leaves of the previous year. Plants in plots of treatments were not inoculated. Harvest data were collected from the two center rows of each plot.

The following materials were used:

Fungicides	Rate per acre in 100 gals. of water
Dyrene 50% WP	2 pounds
Miller 658	1½ pounds
Diathane (Z-78)	1½ pounds
Manzate	1½ pounds
Copper A	4 pounds

Minor elements	
Copper sulfate	(Applied at rates
Zinc sulfate	(comparable to
Manganese sulfate	(formulation

Spray treatments were made every 10 days or after one-half inch of rain, whichever occurred first. The materials were applied in the plots with a small ($2\frac{1}{2}$ gallon) knapsack sprayer, at a pressure of 60 PSI. The spray cans were equipped with a pressure gauge and valve to permit the introduction of air from a portable compressor. Special spray wands were constructed so that the material was applied from 3 nozzles, one on top of the row and one on each side of the row. The material was applied at the recommended rate in water, at the equivalent of 100 gallons per acre. Each row of the four-row plot was sprayed individually. The first spray was applied July 13, at which time the first spots appeared on the foliage. Seven sprays were applied, ending September 9.

RESULTS

The plots sprayed with copper sulfate showed extreme leaf burning seven days after the first treatment. In later applications of this material, the pH was adjusted to 6.5-7.0, resulting in less leaf burning or none at all.

Leaf spot symptoms were apparent following inoculation, but sufficient blighting for satisfactory disease reading on the experiment did not occur until September. By August 25 the leaf spot symptoms were moderately severe in the inoculated border rows and rows separating plots. Immediately after this date, a two-week period of rain and high temperature occurred. Leaf spot readings were made September 9 (table 1).

The plots were harvested October 10, at which time the roots were weighed and samples were taken for sugar analysis (table 1).

The root yields showed significant differences at the 1-percent level by the F test. When all of the treatment means were ranked, and the means compared using the S-N-K multiple range test (table 1), treatment with Copper A resulted in the highest root yield; but differences between fungicides were not significant.

The sugar analysis data proved to be significant at the 1-percent level by the F test. Ranking the treatment means and comparing the means with the S-N-K multiple range test, significant differences (table 1) are apparent at the 1-percent level. Manzate significantly increased percent sugar above that of the check, Diathane, and Miller 658.

The adverse effect of copper sulfate on root yield can be attributed to leaf injury. The relation of the copper sulfate to the percent of sugar should be further investigated.

Table 1. The Sugar Beet Yield in Plots Treated 7 Times with Different Fungicides or Minor Elements for the Control of Cercospora Leaf Spot on Sugar Beets at the Rosemount Experiment Station, 1960.

Treatments	Av. tons per acre		Av. % sugar			Tons sugar per acre	Disease Ratings**
Ranked means level of significance*		5%		5%	1%		
Copper A	14.36	a	15.0	a	ab	2.16	1.00
Manzate	13.94	ab	15.4	a	a	2.14	1.14
Dyrene	13.92	ab	15.1	a	ab	2.10	1.28
Miller 658	13.90	ab	14.5	b	b	2.02	1.28
Diathane (Z-78)	13.48	abc	14.5	b	b	1.95	2.00
Manganese sulfate	12.62	abc	14.4	b	b	1.82	2.71
Check (non-inoculated)	12.36	abc	14.6	b	b	1.80	3.00
Zinc sulfate	12.08	bc	13.8	c	c	1.67	3.57
Copper sulfate	11.62	c	15.1	a	ab	1.71	1.85
Check (inoculated)	-	-	-	-	-	-	4.00

* Treatments not including similar letters are significantly different at the 1-or 5-percent level (S-N-K multiple range test).
Data significant at the 1-percent level (F test).

**Scale: 0 - no leaf spot visible
1 - very few small leaf spots
2 - more than 1
3 - leaf spots numerous
4 - leaf spots numerous, with some dead areas
5 - leaf spots numerous, with large dead areas
6 - same [redacted] 5 but with dead leaves
7 - most of the plants with dead leaves

Manganese sulfate did not significantly affect yield or percent of sugar. Zinc sulfate treatment reduced yield of roots and percent sucrose.

CONCLUSIONS

In this experiment which was conducted under a moderate infestation of cercospora leaf spot disease of sugar beets, none of the fungicides increased the yield of roots of American S-3 significantly above that of the untreated check; however, there was a trend for increase in root yield with leaf spot control.

Manzate significantly (1% level) increased the percent of sugar over that of the check, Diathane, and Miller 658. At the 5-percent level, Manzate, Dyrene, and Copper A were significantly better than the check, Diathane, and Miller 658.